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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	**MJ21US**
First Inventor	**KIA SILVERBROOK**
Title	**PRINTED MEDIA PRODUCTION**
Express Mail Label No.	EK126698644US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231

1. [X] Fee Transmittal Form (e.g., PTO/SB/17) *(Submit an original and a duplicate for fee processing)*
2. [X] Applicant claims small entity status. See 37 CFR 1.27.
3. [X] Specification [*Total Pages* 19] *(preferred arrangement set forth below)*
   - Descriptive title of the invention
   - Cross Reference to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to sequence listing, a table, or a computer program listing appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
4. [X] Drawing(s) *(35 U.S.C. 113)* [*Total Sheets* 27]
5. Oath or Declaration [*Total Pages* 2]
   a. [X] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 CFR 1.63 (d)) *(for continuation/divisional with Box 17 completed)*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1 33(b).
6. [ ] Application Data Sheet. See 37 CFR 1.76
7. [ ] CD-ROM or CD-R in duplicate, large table or Computer Program *(Appendix)*
8. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. [ ] Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. [ ] CD-ROM or CD-R (2 copies); or
      ii. [ ] paper
   c. [ ] Statements verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

9. [X] Assignment Papers (cover sheet & document(s))
10. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
11. [ ] English Translation Document *(if applicable)*
12. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
13. [ ] Preliminary Amendment
14. [ ] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
15. [X] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. [ ] Other: .....

17. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:*

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No _____/_____

Prior application information Examiner _____ Group / Art Unit _____

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

18. CORRESPONDENCE ADDRESS

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Signature		*Date*	**October 18, 2000**

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FEE TRANSMITTAL for FY 2001

Patent fees are subject to annual revision

TOTAL AMOUNT OF PAYMENT ($) 395

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	KIA SILVERBROOK
Examiner Name	
Group Art Unit	
Attorney Docket No.	MJ21US

METHOD OF PAYMENT

1. ☐ The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:
   Deposit Account Number
   Deposit Account Name
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   ☐ Applicant claims small entity status. See 37 CFR 1.27

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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	710	201	355	Utility filing fee	355
106	320	206	160	Design filing fee	
107	490	207	245	Plant filing fee	
108	710	208	355	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($) 355

2. EXTRA CLAIM FEES

		Extra Claims	Fee from below	Fee Paid
Total Claims	5	-20** =	X 9	= 0
Independent Claims	1	- 3** =	X 40	= 0
Multiple Dependent				=

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	80	202	40	Independent claims in excess of 3
104	270	204	135	Multiple dependent claim, if not paid
109	80	209	40	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0

**or number previously paid, if greater, For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for *ex parte* reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	390	216	195	Extension for reply within second month	
117	890	217	445	Extension for reply within third month	
118	1,390	218	695	Extension for reply within fourth month	
128	1,890	228	945	Extension for reply within fifth month	
119	310	219	155	Notice of Appeal	
120	310	220	155	Filing a brief in support of an appeal	
121	270	221	135	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,240	241	620	Petition to revive - unintentional	
142	1,240	242	620	Utility issue fee (or reissue)	
143	440	243	220	Design issue fee	
144	600	244	300	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	40
146	710	246	355	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	710	249	355	For each additional invention to be examined (37 CFR § 1.129(b))	
179	710	279	355	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	

Other fee (specify) _____

* Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 40

SUBMITTED BY				Complete (if applicable)	
Name (Print/Type)	Kia Silverbrook	Registration No. (Attorney/Agent)		Telephone	+61-2-9818-6633
Signature				Date	October 18, 2000

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TITLE OF THE INVENTION

Printed Media Production

INVENTOR

Kia Silverbrook

CO-PENDING APPLICATIONS

Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending applications filed by the applicant or assignee of the present invention simultaneously with the present application:

NPA001US, NPA002US, NPA003US, NPA004US, NPA005US, NPA006US, NPA007US, NPA008US, NPA009US, NPA010US, NPA012US, NPA016US, NPA017US, NPA018US, NPA019US, NPA020US, NPA021US, NPA030US, NPA035US, NPA048US, NPA050US, NPA051US, NPA052US, NPA075US, NPB001US, NPB002US, NPK002US, NPK003US, NPK004US, NPK005US, NPK007US, NPM001US, NPM002US, NPM003US, NPM004US, NPN001US, NPN002US, NPN003US, NPP001US, NPP002US, NPP003US, NPP005US, NPP006US, NPP007US, NPP008US, NPP016US, NPP017US, NPP018US, NPP019US, NPS001US, NPS003US, NPS020US, NPT001US, NPT002US, NPT003US, NPT004US, NPX001US, NPX003US, NPX008US, NPX011US, NPX014US, NPX016US, NPX020US, NPX022US, IJ52US, IJM52US, MJ10US, MJ11US, MJ12US, MJ13US, MJ14US, MJ15US, MJ34US, MJ47US, MJ52US, MJ58US, MJ62US, MJ63US, MJ64US, MJ65US, MJ66US, PAK04US, PAK05US, PAK06US, PAK07US, PAK08US, PEC01US, PEC02US, PP01US, PP02US, PP03US, PP04US, PP07US, PP08US, PP09US, PP10US, PP11US, PP12US, PP13US, PP14US, PP15US, PP16US, PP17US.

The disclosures of these co-pending applications are incorporated herein by cross-reference. Each application is temporarily identified by its docket number. This will be replaced by the corresponding USSN when available.

FIELD OF THE INVENTION

The present invention relates to printed media production and in particular ink jet printers.

BACKGROUND TO THE INVENTION

Ink jet printers are a well known and widely used form of printed media production. Colorants, usually ink, are fed to an array of micro-processor controlled nozzles on a printhead. As the print head passes over the media, colorant is ejected from the array of nozzles to produce the printing on the media substrate.

Printer performance depends on factors such as operating cost, print quality, operating speed and ease of use. The mass, frequency and velocity of individual ink drops ejected from the nozzles will affect these performance parameters. In general terms, smaller, faster droplets ejected at higher frequency provide cost, speed and print quality advantages.

In light of this, it has been an overriding aim of printhead design to reduce the size of the ink nozzles and thereby the size of the droplets ejected. Recently, the array of nozzles has been formed using microelectromechanical systems (MEMS) technology, which have mechanical structures with sub-micron thicknesses. This allows the production of printheads that can rapidly eject ink droplets sized in the picolitre (x 10^{-12} litre) range.

While the microscopic structures of these printheads can provide high speeds and good print quality at relatively low costs, their size makes the nozzles extremely fragile and vulnerable to damage from the slightest contact with finger, dust

or the media substrate. This can make the printheads impractical for many applications where a certain level of robustness is necessary.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides a nozzle guard for an ink jet printer printhead with an array of nozzles and respective colorant ejection means for ejecting colorant onto a substrate to be printed, wherein the nozzle guard is adapted to be positioned to inhibit damaging contact with the exterior of the array of nozzles.

In this specification the term "nozzle" is to be understood as an element defining an opening and not the opening itself.

Preferably, the nozzle guard has a shield covering the exterior of the nozzles wherein the shield has an array of passages in registration with the array of nozzles so as not to impede the normal trajectory of the colorant ejected from each nozzle. In a further preferred form, the shield is formed from silicon.

The nozzle guard may further include fluid inlet openings for directing fluid through the passages, to inhibit the build up of foreign particles on the nozzle array.

The nozzle guard may include a support means for supporting the nozzle shield on the printhead. The support means may be formed integrally with the shield, the support means comprising a pair of spaced support elements one being arranged at each end of the nozzle shield.

In this embodiment, the fluid inlet openings may be arranged in one of the support elements.

It will be appreciated that, when air is directed through the openings, over the nozzle array and out through the passages, the build up of foreign particles on the nozzle array is inhibited.

The fluid inlet openings may be arranged in the support element remote from a bond pad of the nozzle array.

The invention extends also to a printhead for an ink jet printer, the printhead including:

an array of nozzles and respective colorant ejection means for ejecting colorant onto a media substrate to be printed; and,

a nozzle guard, as described above, positioned to inhibit damaging contact with the exterior of the array of nozzles.

By providing a nozzle guard on the printhead, the nozzle structures can be protected from being touched or bumped against most other surfaces. To optimize the protection provided, the guard forms a flat shield covering the exterior side of the nozzles wherein the shield has an array of passages big enough to allow the ejection of colorant droplets but small enough to prevent inadvertant contact or the ingress of most dust particles. By forming the shield from silicon, its coefficient of thermal expansion substantially matches that of the nozzle array. This will help to prevent the array of passages in the shield from falling out of register with the nozzle array. Using silicon also allows the shield to be accurately micro-machined using MEMS techniques. Furthermore, silicon is very strong and substantially non deformable.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are now described, by way of example only, with reference to the accompanying drawings in which:-

Figure 1 shows a three dimensional, schematic view of a nozzle assembly for an ink jet printhead;

Figures 2 to 4 show a three dimensional, schematic illustration of an operation of the nozzle assembly of Figure 1;

Figure 5 shows a three dimensional view of a nozzle array constituting an ink jet printhead;

Figure 6 shows, on an enlarged scale, part of the array of Figure 5;

Figure 7 shows a three dimensional view of an ink jet printhead including a nozzle guard, in accordance with the invention;

Figures 8a to 8r show three dimensional views of steps in the manufacture of a nozzle assembly of an ink jet printhead;

Figures 9a to 9r show sectional side views of the manufacturing steps;

Figures 10a to 10k show layouts of masks used in various steps in the manufacturing process;

Figures 11a to 11c show three dimensional views of an operation of the nozzle assembly manufactured according to the method of Figures 8 and 9; and

Figures 12a to 12c show sectional side views of an operation of the nozzle assembly manufactured according to the method of Figures 8 and 9.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring initially to Figure 1 of the drawings, a nozzle assembly, in accordance with the invention is designated generally by the reference numeral 10. An ink jet printhead has a plurality of nozzle assemblies 10 arranged in an array 14 (Figures 5 and 6) on a silicon substrate 16. The array 14 will be described in greater detail below.

The assembly 10 includes a silicon substrate or wafer 16 on which a dielectric layer 18 is deposited. A CMOS passivation layer 20 is deposited on the dielectric layer 18.

Each nozzle assembly 10 includes a nozzle 22 defining a nozzle opening 24, a connecting member in the form of a lever arm 26 and an actuator 28. The lever arm 26 connects the actuator 28 to the nozzle 22.

As shown in greater detail in Figures 2 to 4, the nozzle 22 comprises a crown portion 30 with a skirt portion 32 depending from the crown portion 30. The skirt portion 32 forms part of a peripheral wall of a nozzle chamber 34. The nozzle opening 24 is in fluid communication with the nozzle chamber 34. It is to be noted that the nozzle opening 24 is surrounded by a raised rim 36 which "pins" a meniscus 38 (Figure 2) of a body of ink 40 in the nozzle chamber 34.

An ink inlet aperture 42 (shown most clearly in Figure 6 of the drawing) is defined in a floor 46 of the nozzle chamber 34. The aperture 42 is in fluid communication with an ink inlet channel 48 defined through the substrate 16.

A wall portion 50 bounds the aperture 42 and extends upwardly from the floor portion 46. The skirt portion 32, as indicated above, of the nozzle 22 defines a first part

of a peripheral wall of the nozzle chamber 34 and the wall portion 50 defines a second part of the peripheral wall of the nozzle chamber 34.

The wall 50 has an inwardly directed lip 52 at its free end which serves as a fluidic seal which inhibits the escape of ink when the nozzle 22 is displaced, as will be described in greater detail below. It will be appreciated that, due to the viscosity of the ink 40 and the small dimensions of the spacing between the lip 52 and the skirt portion 32, the inwardly directed lip 52 and surface tension function as an effective seal for inhibiting the escape of ink from the nozzle chamber 34.

The actuator 28 is a thermal bend actuator and is connected to an anchor 54 extending upwardly from the substrate 16 or, more particularly from the CMOS passivation layer 20. The anchor 54 is mounted on conductive pads 56 which form an electrical connection with the actuator 28.

The actuator 28 comprises a first, active beam 58 arranged above a second, passive beam 60. In a preferred embodiment, both beams 58 and 60 are of, or include, a conductive ceramic material such as titanium nitride (TiN).

Both beams 58 and 60 have their first ends anchored to the anchor 54 and their opposed ends connected to the arm 26. When a current is caused to flow through the active beam 58 thermal expansion of the beam 58 results. As the passive beam 60, through which there is no current flow, does not expand at the same rate, a bending moment is created causing the arm 26 and, hence, the nozzle 22 to be displaced downwardly towards the substrate 16 as shown in Figure 3. This causes an ejection of ink through the nozzle opening 24 as shown at 62. When the source of heat is removed from the active beam 58, i.e. by stopping current flow, the nozzle 22 returns to its

quiescent position as shown in Figure 4. When the nozzle 22 returns to its quiescent position, an ink droplet 64 is formed as a result of the breaking of an ink droplet neck as illustrated at 66 in Figure 4. The ink droplet 64 then travels on to the print media such as a sheet of paper. As a result of the formation of the ink droplet 64, a "negative" meniscus is formed as shown at 68 in Figure 4 of the drawings. This "negative" meniscus 68 results in an inflow of ink 40 into the nozzle chamber 34 such that a new meniscus 38 (Figure 2) is formed in readiness for the next ink drop ejection from the nozzle assembly 10.

Referring now to Figures 5 and 6 of the drawings, the nozzle array 14 is described in greater detail. The array 14 is for a four color printhead. Accordingly, the array 14 includes four groups 70 of nozzle assemblies, one for each color. Each group 70 has its nozzle assemblies 10 arranged in two rows 72 and 74. One of the groups 70 is shown in greater detail in Figure 6.

To facilitate close packing of the nozzle assemblies 10 in the rows 72 and 74, the nozzle assemblies 10 in the row 74 are offset or staggered with respect to the nozzle assemblies 10 in the row 72. Also, the nozzle assemblies 10 in the row 72 are spaced apart sufficiently far from each other to enable the lever arms 26 of the nozzle assemblies 10 in the row 74 to pass between adjacent nozzles 22 of the assemblies 10 in the row 72. It is to be noted that each nozzle assembly 10 is substantially dumbbell shaped so that the nozzles 22 in the row 72 nest between the nozzles 22 and the actuators 28 of adjacent nozzle assemblies 10 in the row 74.

Further, to facilitate close packing of the nozzles 22 in the rows 72 and 74, each nozzle 22 is substantially hexagonally shaped.

It will be appreciated by those skilled in the art that, when the nozzles 22 are displaced towards the substrate 16, in use, due to the nozzle opening 24 being at a slight angle with respect to the nozzle chamber 34 ink is ejected slightly off the perpendicular. It is an advantage of the arrangement shown in Figures 5 and 6 of the drawings that the actuators 28 of the nozzle assemblies 10 in the rows 72 and 74 extend in the same direction to one side of the rows 72 and 74. Hence, the ink ejected from the nozzles 22 in the row 72 and the ink ejected from the nozzles 22 in the row 74 are offset with respect to each other by the same angle resulting in an improved print quality.

Also, as shown in Figure 5 of the drawings, the substrate 16 has bond pads 76 arranged thereon which provide the electrical connections, via the pads 56, to the actuators 28 of the nozzle assemblies 10. These electrical connections are formed via the CMOS layer (not shown).

Referring to Figure 7, a nozzle guard according to the present invention is shown. With reference to the previous drawings, like reference numerals refer to like parts, unless otherwise specified.

A nozzle guard 80 is mounted on the silicon substrate 16 of the array 14. The nozzle guard 80 includes a shield 82 having a plurality of passages 84 defined therethrough. The passages 84 are in register with the nozzle openings 24 of the nozzle assemblies 10 of the array 14 such that, when ink is ejected from any one of the nozzle openings 24, the ink passes through the associated passage before striking the print media.

The guard 80 is silicon so that it has the necessary strength and rigidity to protect the nozzle array 14 from damaging contact with paper, dust or the users' fingers. By

forming the guard from silicon, its coefficient of thermal expansion substantially matches that of the nozzle array. This aims to prevent the passages 84 in the shield 82 from falling out of register with the nozzle array14 as the printhead heats up to its normal operating temperature. Silicon is also well suited to accurate micro-machining using MEMS techniques discussed in greater detail below in relation to the manufacture of the nozzle assemblies10.

The shield 82 is mounted in spaced relationship relative to the nozzle assemblies 10 by limbs or struts 86. One of the struts 86 has air inlet openings 88 defined therein.

In use, when the array 14 is in operation, air is charged through the inlet openings 88 to be forced through the passages 84 together with ink travelling through the passages 84.

The ink is not entrained in the air as the air is charged through the passages 84 at a different velocity from that of the ink droplets 64. For example, the ink droplets 64 are ejected from the nozzles 22 at a velocity of approximately 3m/s. The air is charged through the passages 84 at a velocity of approximately 1m/s.

The purpose of the air is to maintain the passages 84 clear of foreign particles. A danger exists that these foreign particles, such as dust particles, could fall onto the nozzle assemblies 10 adversely affecting their operation. With the provision of the air inlet openings 88 in the nozzle guard 80 this problem is, to a large extent, obviated.

Referring now to Figures 8 to 10 of the drawings, a process for manufacturing the nozzle assemblies 10 is described.

Starting with the silicon substrate or wafer 16, the dielectric layer 18 is deposited on a surface of the wafer 16. The dielectric layer 18 is in the form of approximately 1.5

microns of CVD oxide. Resist is spun on to the layer 18 and the layer 18 is exposed to mask 100 and is subsequently developed.

After being developed, the layer 18 is plasma etched down to the silicon layer 16. The resist is then stripped and the layer 18 is cleaned. This step defines the ink inlet aperture 42.

In Figure 8b of the drawings, approximately 0.8 microns of aluminum 102 is deposited on the layer 18. Resist is spun on and the aluminum 102 is exposed to mask 104 and developed. The aluminum 102 is plasma etched down to the oxide layer 18, the resist is stripped and the device is cleaned. This step provides the bond pads and interconnects to the ink jet actuator 28. This interconnect is to an NMOS drive transistor and a power plane with connections made in the CMOS layer (not shown).

Approximately 0.5 microns of PECVD nitride is deposited as the CMOS passivation layer 20. Resist is spun on and the layer 20 is exposed to mask 106 whereafter it is developed. After development, the nitride is plasma etched down to the aluminum layer 102 and the silicon layer 16 in the region of the inlet aperture 42. The resist is stripped and the device cleaned.

A layer 108 of a sacrificial material is spun on to the layer 20. The layer 108 is 6 microns of photo-sensitive polyimide or approximately 4 μm of high temperature resist. The layer 108 is softbaked and is then exposed to mask 110 whereafter it is developed. The layer 108 is then hardbaked at 400°C for one hour where the layer 108 is comprised of polyimide or at greater than 300°C where the layer 108 is high temperature resist. It is to be noted in the drawings that the pattern-dependent

distortion of the polyimide layer 108 caused by shrinkage is taken into account in the design of the mask 110.

In the next step, shown in Figure 8e of the drawings, a second sacrificial layer 112 is applied. The layer 112 is either 2 μm of photo-sensitive polyimide which is spun on or approximately 1.3 μm of high temperature resist. The layer 112 is softbaked and exposed to mask 114. After exposure to the mask 114, the layer 112 is developed. In the case of the layer 112 being polyimide, the layer 112 is hardbaked at 400°C for approximately one hour. Where the layer 112 is resist, it is hardbaked at greater than 300°C for approximately one hour.

A 0.2 micron multi-layer metal layer 116 is then deposited. Part of this layer 116 forms the passive beam 60 of the actuator 28.

The layer 116 is formed by sputtering 1,000Å of titanium nitride (TiN) at around 300°C followed by sputtering 50Å of tantalum nitride (TaN). A further 1,000Å of TiN is sputtered on followed by 50Å of TaN and a further 1,000Å of TiN.

Other materials which can be used instead of TiN are TiB_2, $MoSi_2$ or (Ti, Al)N.

The layer 116 is then exposed to mask 118, developed and plasma etched down to the layer 112 whereafter resist, applied for the layer 116, is wet stripped taking care not to remove the cured layers 108 or 112.

A third sacrificial layer 120 is applied by spinning on 4 μm of photo-sensitive polyimide or approximately 2.6 μm high temperature resist. The layer 120 is softbaked whereafter it is exposed to mask 122. The exposed layer is then developed followed by hard baking. In the case of polyimide, the layer 120 is hardbaked at 400°C for approximately one hour or at greater than 300°C where the layer 120 comprises resist.

A second multi-layer metal layer 124 is applied to the layer 120. The constituents of the layer 124 are the same as the layer 116 and are applied in the same manner. It will be appreciated that both layers 116 and 124 are electrically conductive layers.

The layer 124 is exposed to mask 126 and is then developed. The layer 124 is plasma etched down to the polyimide or resist layer 120 whereafter resist applied for the layer 124 is wet stripped taking care not to remove the cured layers 108, 112 or 120. It will be noted that the remaining part of the layer 124 defines the active beam 58 of the actuator 28.

A fourth sacrificial layer 128 is applied by spinning on 4 μm of photo-sensitive polyimide or approximately 2.6μm of high temperature resist. The layer 128 is softbaked, exposed to the mask 130 and is then developed to leave the island portions as shown in Figure 9k of the drawings. The remaining portions of the layer 128 are hardbaked at 400°C for approximately one hour in the case of polyimide or at greater than 300°C for resist.

As shown in Figure 8l of the drawing a high Young's modulus dielectric layer 132 is deposited. The layer 132 is constituted by approximately 1μm of silicon nitride or aluminum oxide. The layer 132 is deposited at a temperature below the hardbaked temperature of the sacrificial layers 108, 112, 120, 128. The primary characteristics required for this dielectric layer 132 are a high elastic modulus, chemical inertness and good adhesion to TiN.

A fifth sacrificial layer 134 is applied by spinning on 2μm of photo-sensitive polyimide or approximately 1.3μm of high temperature resist. The layer 134 is

softbaked, exposed to mask 136 and developed. The remaining portion of the layer 134 is then hardbaked at 400°C for one hour in the case of the polyimide or at greater than 300°C for the resist.

The dielectric layer 132 is plasma etched down to the sacrificial layer 128 taking care not to remove any of the sacrificial layer 134.

This step defines the nozzle opening 24, the lever arm 26 and the anchor 54 of the nozzle assembly 10.

A high Young's modulus dielectric layer 138 is deposited. This layer 138 is formed by depositing 0.2μm of silicon nitride or aluminum nitride at a temperature below the hardbaked temperature of the sacrificial layers 108, 112, 120 and 128.

Then, as shown in Figure 8p of the drawings, the layer 138 is anisotropically plasma etched to a depth of 0.35 microns. This etch is intended to clear the dielectric from all of the surface except the side walls of the dielectric layer 132 and the sacrificial layer 134. This step creates the nozzle rim 36 around the nozzle opening 24 which "pins" the meniscus of ink, as described above.

An ultraviolet (UV) release tape 140 is applied. 4μm of resist is spun on to a rear of the silicon wafer 16. The wafer 16 is exposed to mask 142 to back etch the wafer 16 to define the ink inlet channel 48. The resist is then stripped from the wafer 16.

A further UV release tape (not shown) is applied to a rear of the wafer 16 and the tape 140 is removed. The sacrificial layers 108, 112, 120, 128 and 134 are stripped in oxygen plasma to provide the final nozzle assembly 10 as shown in Figures 8r and 9r of the drawings. For ease of reference, the reference numerals illustrated in these two

drawings are the same as those in Figure 1 of the drawings to indicate the relevant parts of the nozzle assembly 10. Figures 11 and 12 show the operation of the nozzle assembly 10, manufactured in accordance with the process described above with reference to Figures 8 and 9 and these figures correspond to Figures 2 to 4 of the drawings.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

I CLAIM:

1. A nozzle guard for an ink jet printer printhead with an array of nozzles and respective colorant ejection means for ejecting colorant onto a substrate to be printed, wherein the nozzle guard is adapted to be positioned on the printhead to inhibit damaging contact with the exterior of the array of nozzles.

2. A nozzle guard according to Claim 1 including a shield covering the exterior of the nozzles wherein the shield has an array of passages in registration with the array of nozzles so as not to impede the normal trajectory of the colorant ejected from each nozzle.

3. A nozzle guard according to Claim 2 wherein the shield is formed from silicon.

4. A nozzle guard according to Claim 2 further including fluid inlet openings for directing fluid through the passages, to inhibit the build up of foreign particles on the nozzle array.

5. A nozzle guard according to Claim 2 further including a support means for supporting the nozzle shield on the printhead.

6. A nozzle guard according to Claim 5 wherein the support means is integrally formed with the shield, the support means including a pair of spaced support elements, one being arranged at each end of the nozzle shield.

7. A nozzle guard according to Claim 6 wherein the fluid inlet openings are arranged in one of the support elements.

8. A nozzle guard according to Claim 2 wherein the fluid inlet openings are arranged in the support element remote from a bond pad of the nozzle array.

9. A printhead for an ink jet printer, the printhead including:

an array of nozzles and respective colorant ejection means for ejecting colorant onto a media substrate to be printed; and,

a nozzle guard positioned to inhibit damaging contact with the exterior of the array of nozzles.

10. A printhead according to Claim 9 wherein the nozzle guard has a shield covering the exterior of the nozzles wherein the shield has an array of passages in registration with the array of nozzles so as not to impede the normal trajectory of the colorant ejected from each nozzle.

11. A printhead according to Claim 10 wherein the shield is formed from silicon.

12. A printhead according to Claim 11 wherein the nozzle guard includes fluid inlet openings for directing fluid through the passages, to inhibit the build up of foreign particles on the nozzle array.

13. A printhead according to Claim 10 wherein the nozzle guard has a support means for supporting the nozzle shield on the printhead.

14. A printhead according to Claim 13 wherein the support means is integrally formed with the shield, the support means comprising a pair of spaced support elements one being arranged at each end of the nozzle shield.

15. A printhead according to Claim 14 wherein the fluid inlet openings are arranged in one of the support elements.

16. A printhead according to Claim 10 wherein the fluid inlet openings are arranged in the support element remote from a bond pad of the nozzle array.

ABSTRACT OF THE DISCLOSURE

A nozzle guard 80 for an ink jet printer printhead with an array 14 of nozzles 10 and respective colorant ejection means for ejecting colorant onto a substrate to be printed, wherein the nozzle guard 80 is adapted to be positioned on the printhead to inhibit damaging contact with the exterior of the array 14 of nozzles 10.

Figure 7

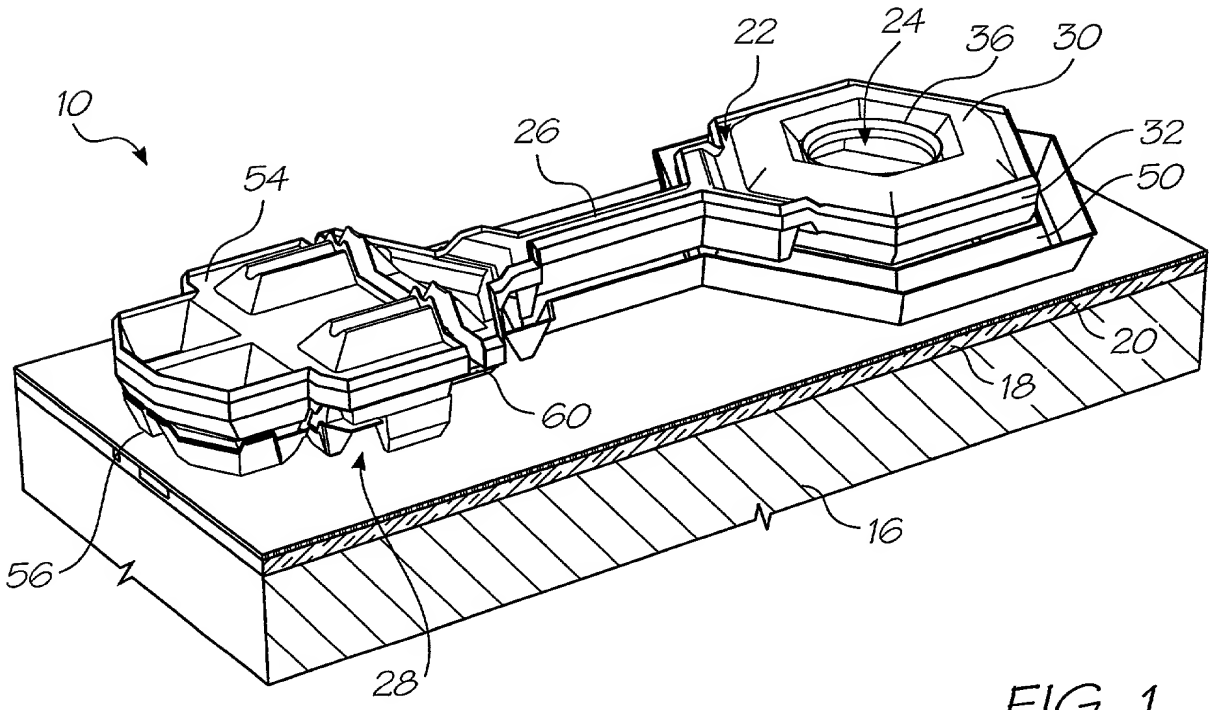

FIG. 1

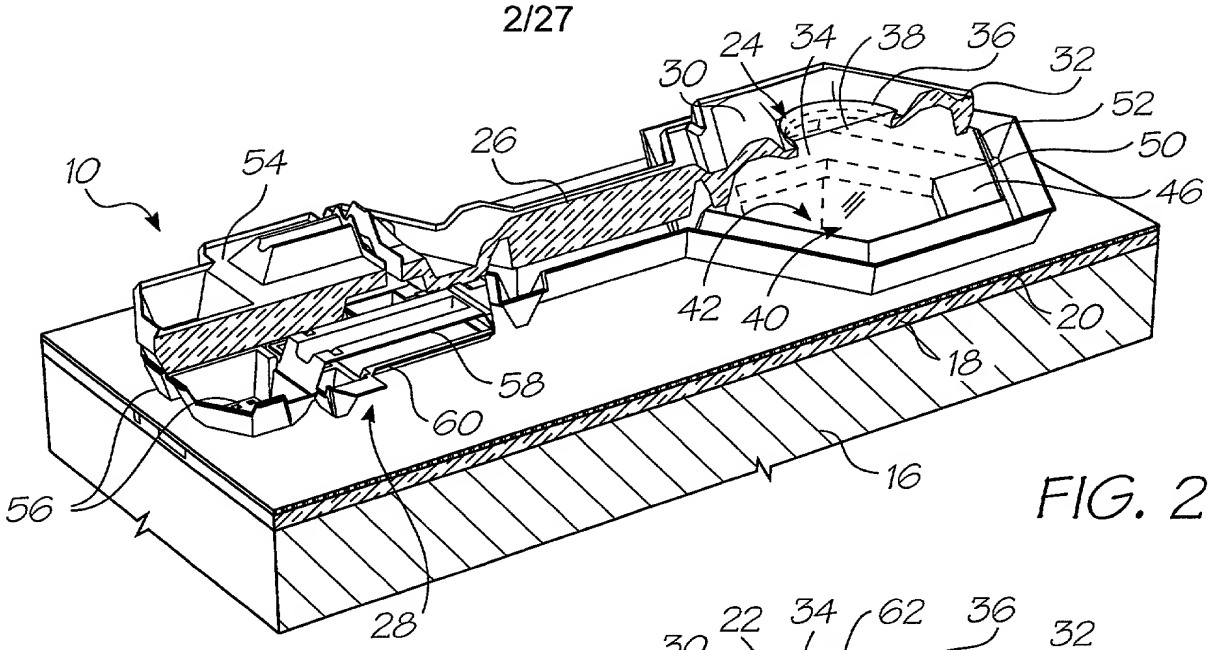

FIG. 2

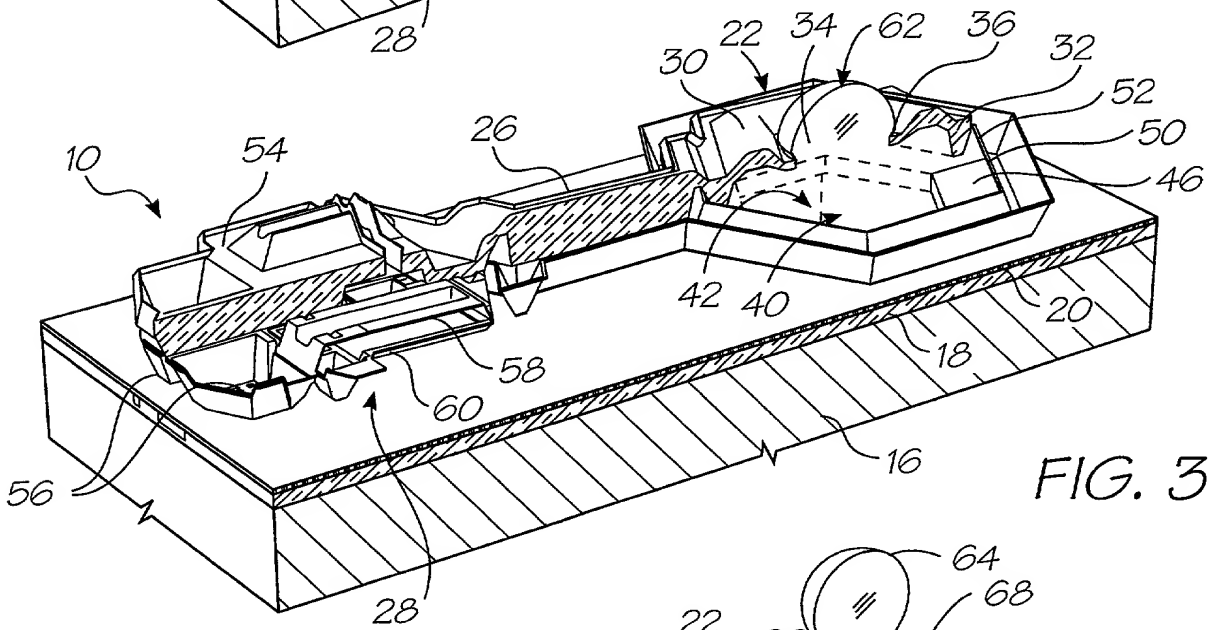

FIG. 3

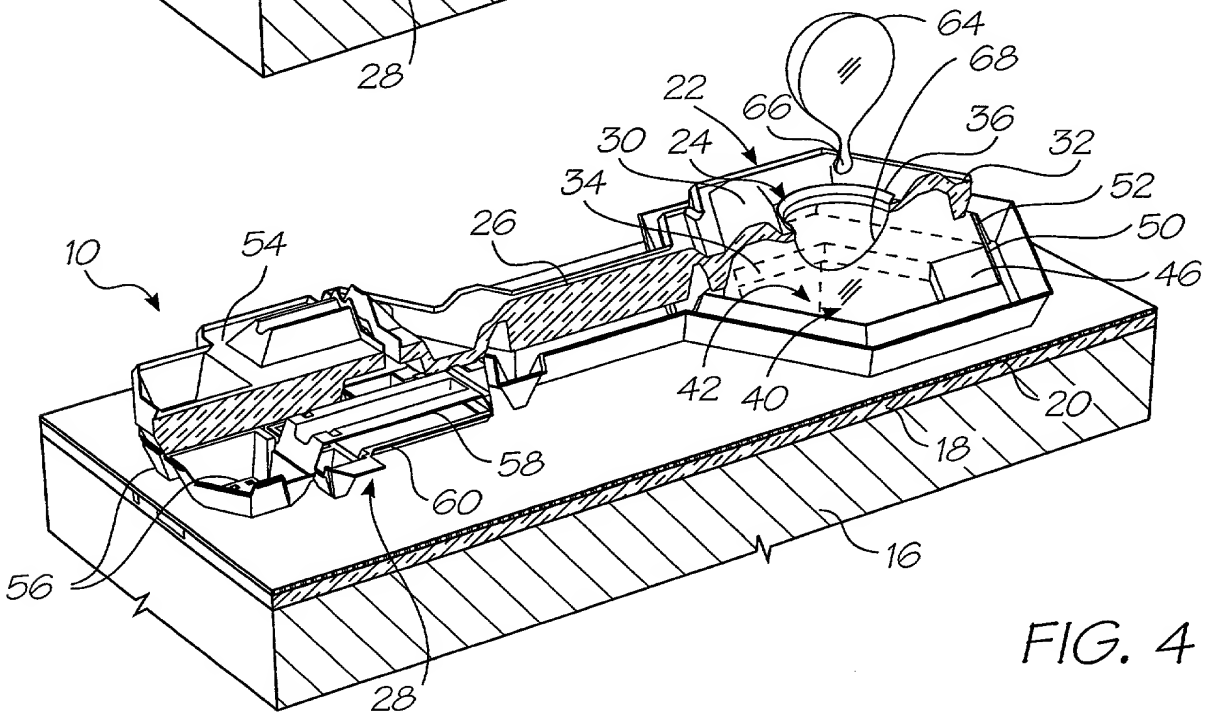

FIG. 4

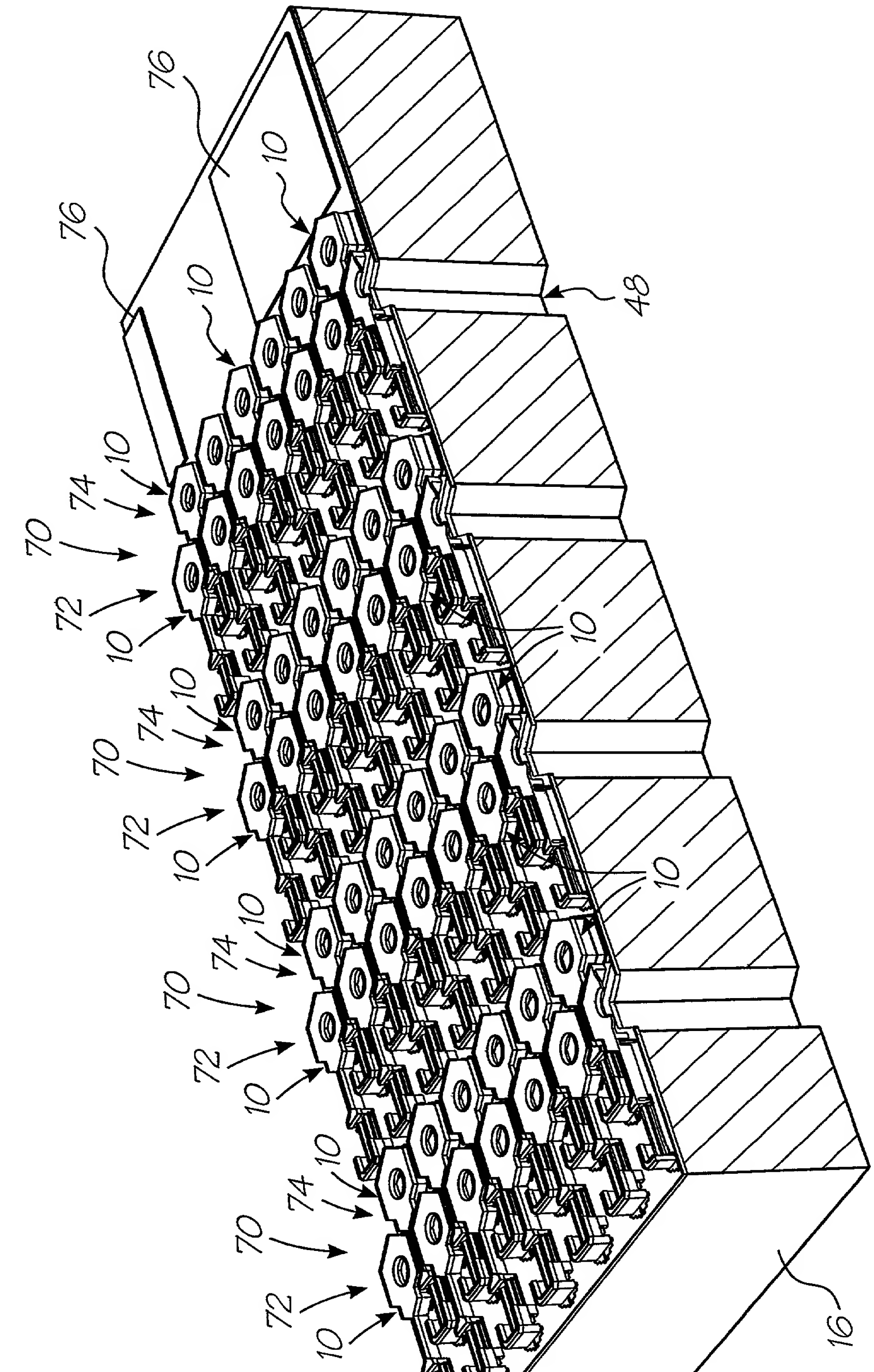
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FIG. 5

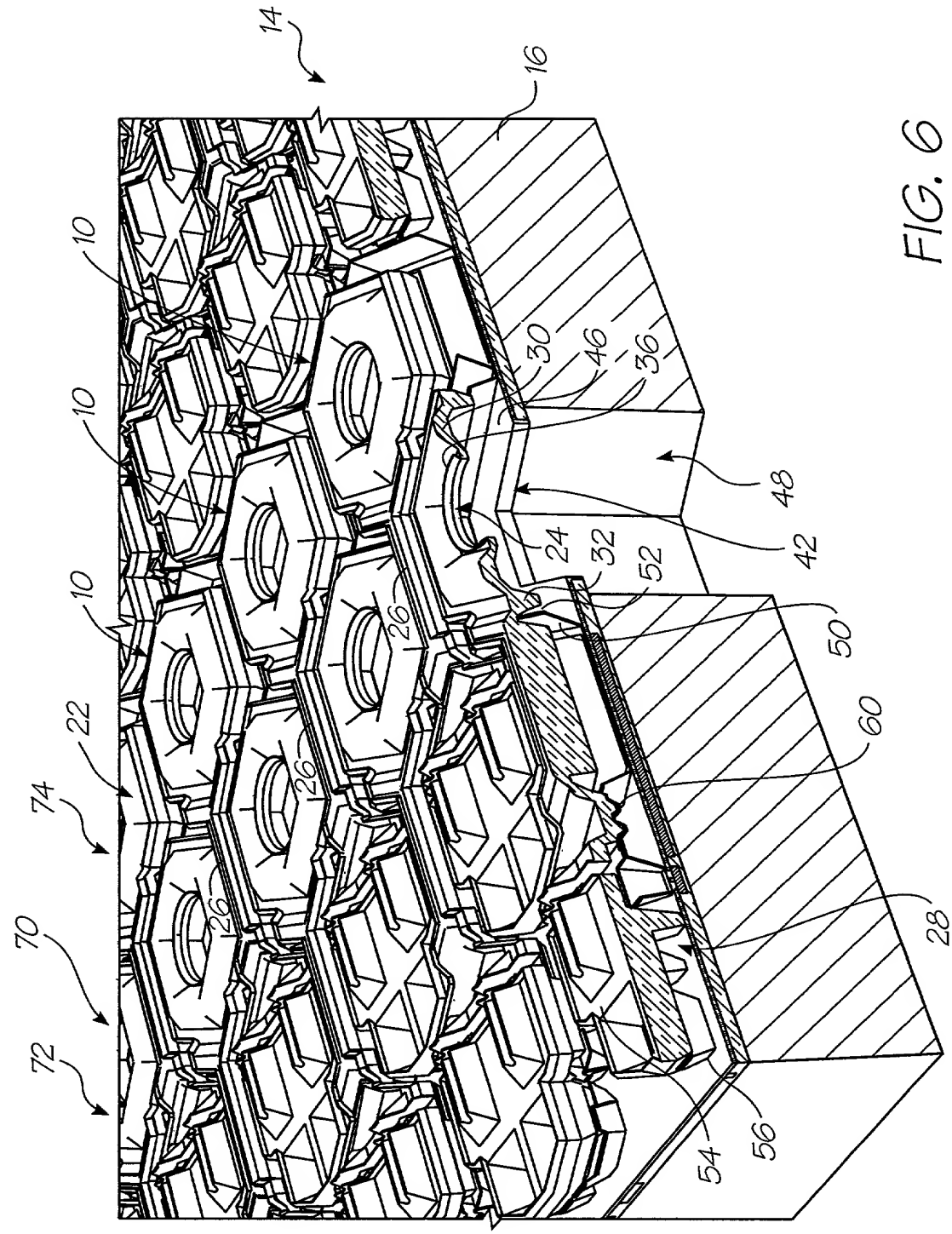
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FIG. 6

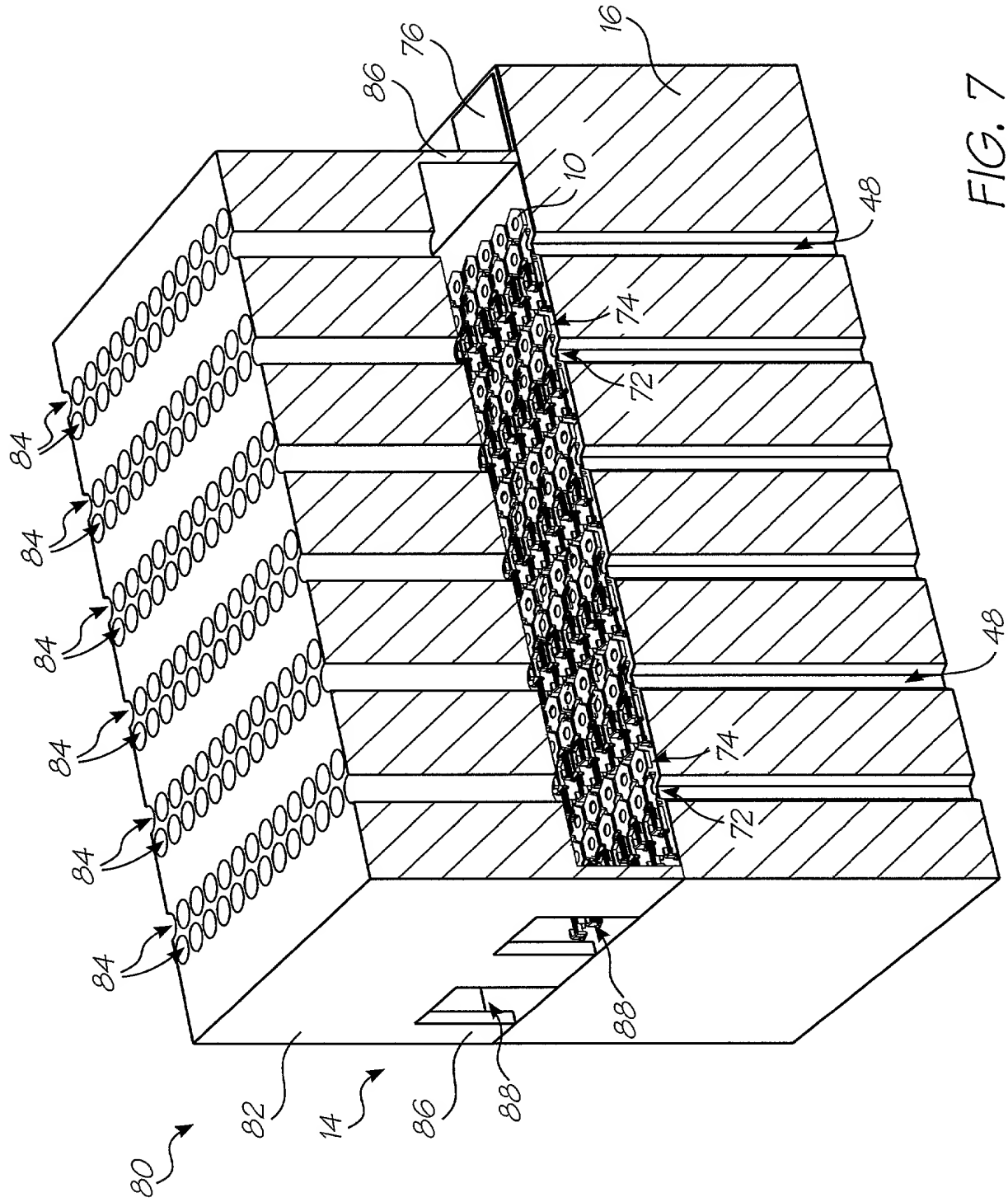

FIG. 7

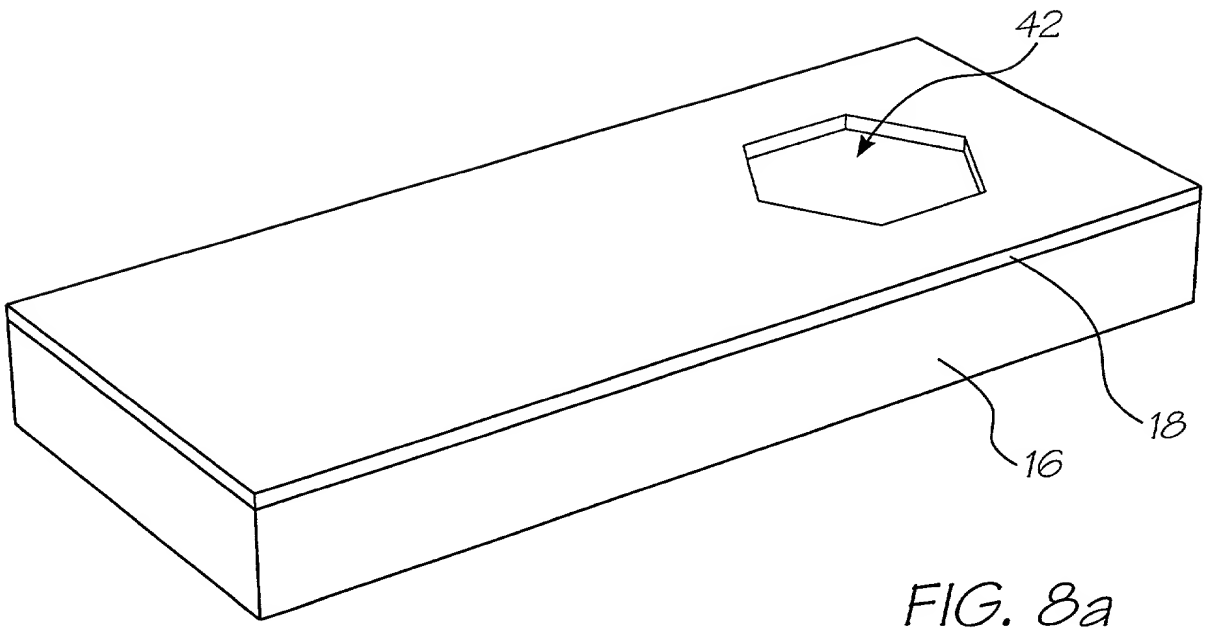

FIG. 8a

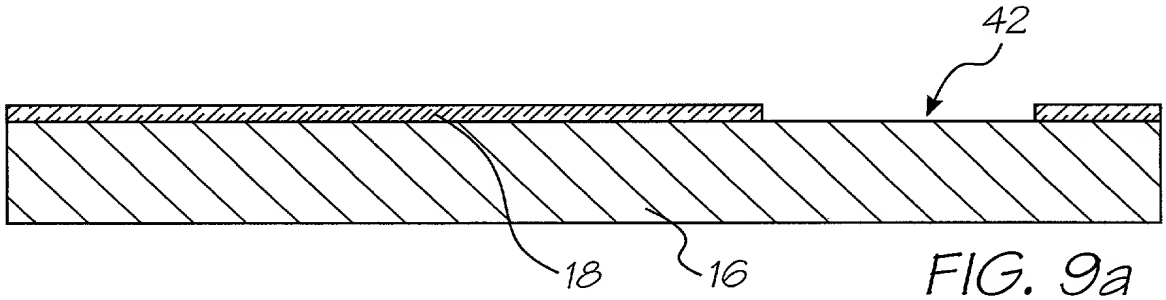

FIG. 9a

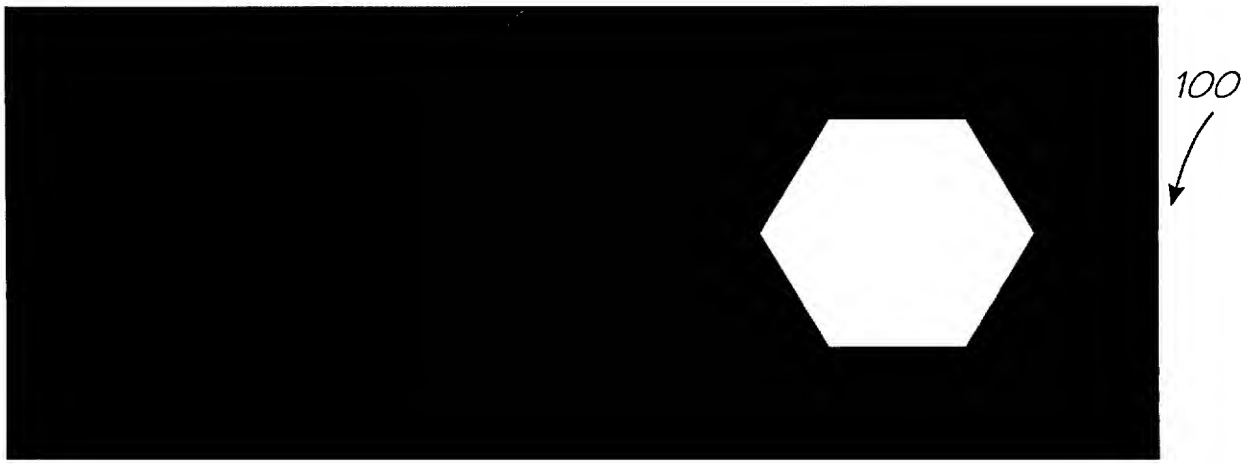

FIG. 10a

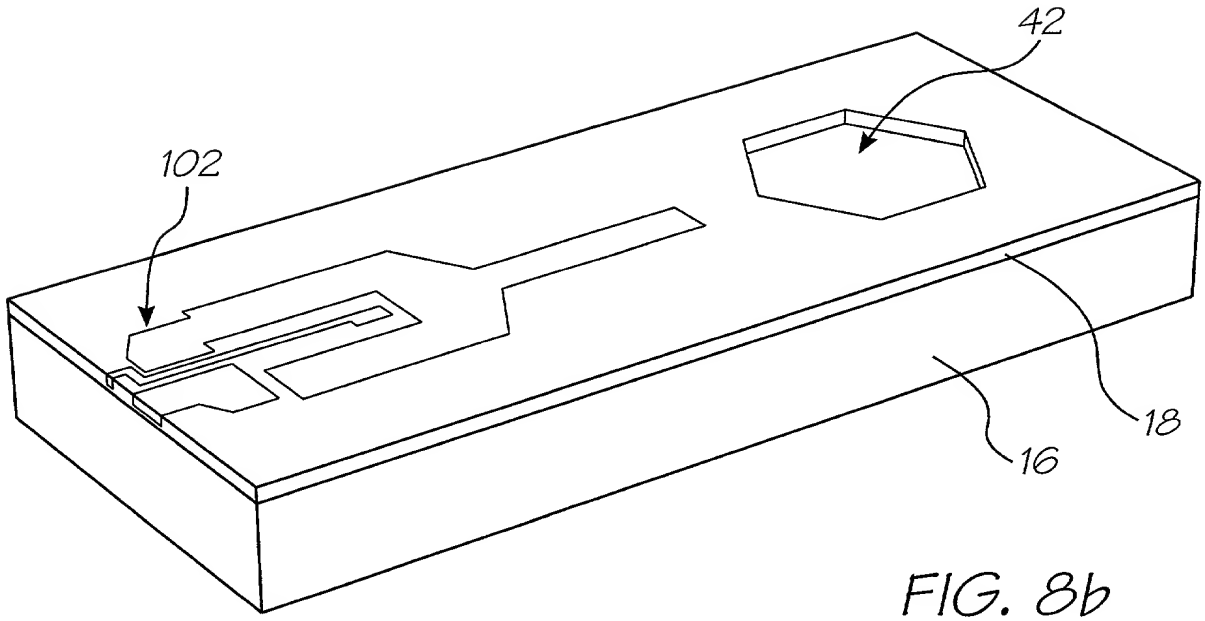

FIG. 8b

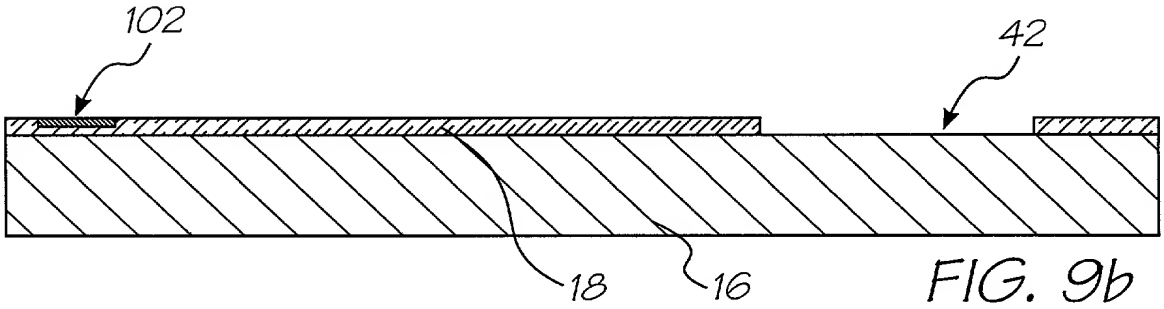

FIG. 9b

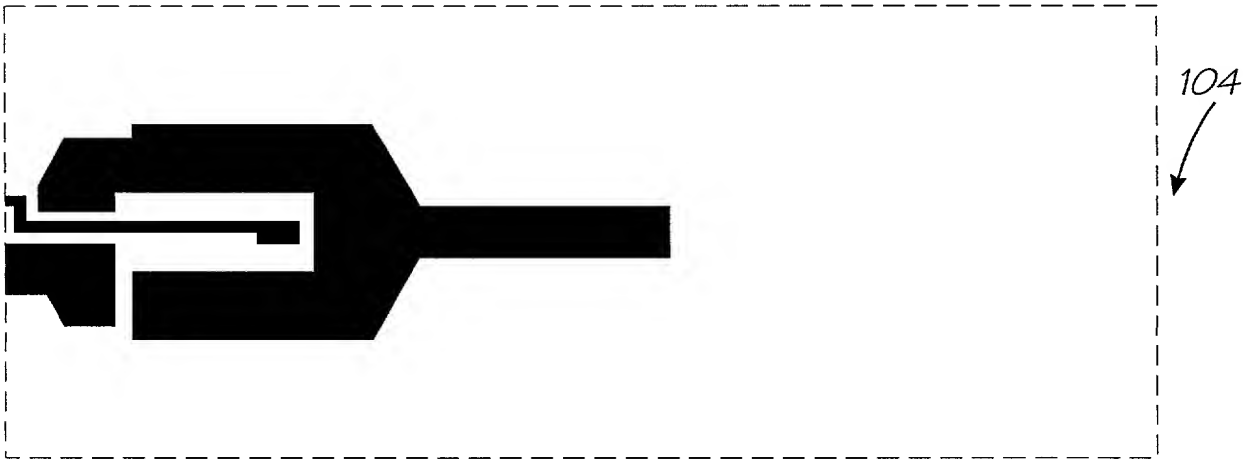

FIG. 10b

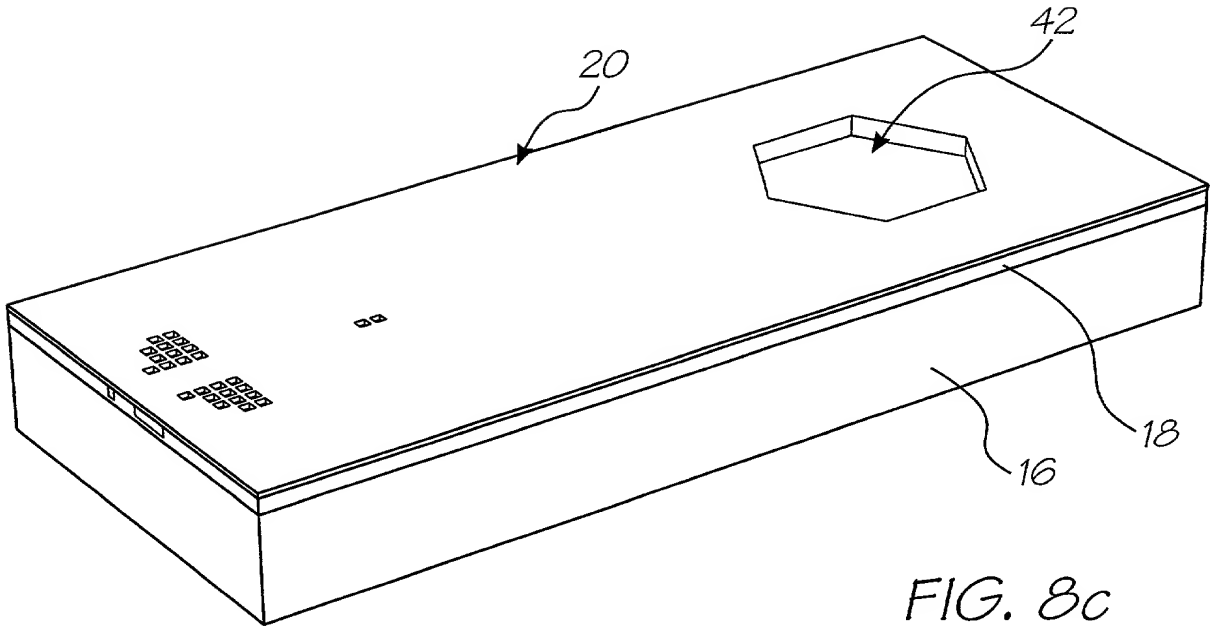

FIG. 8c

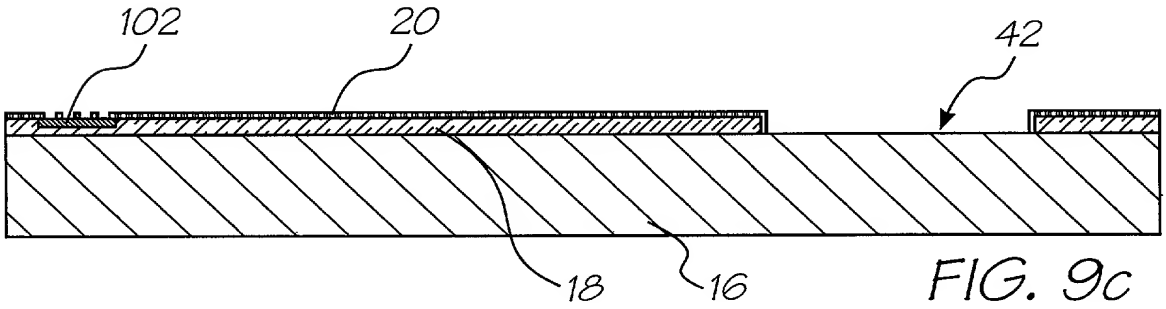

FIG. 9c

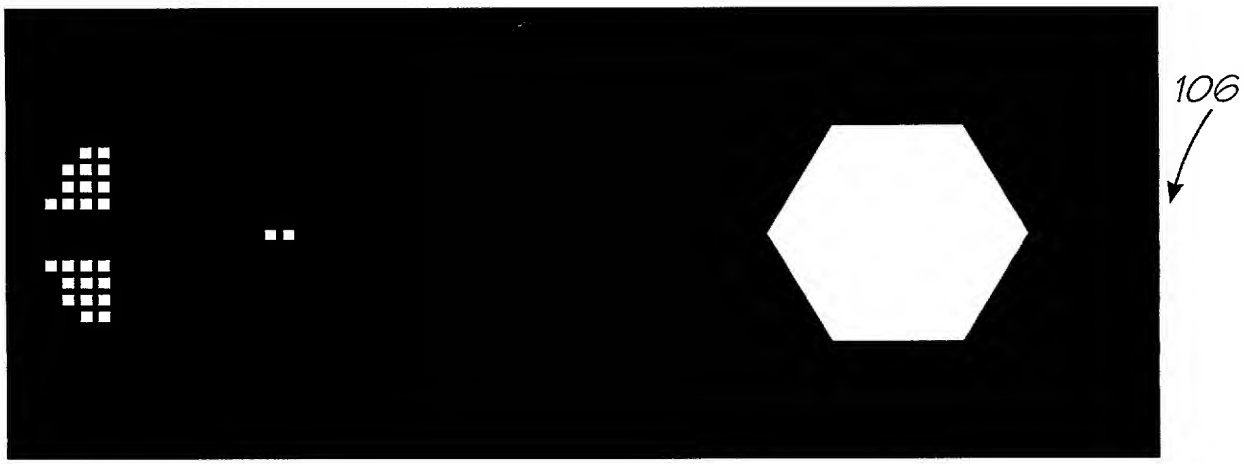

FIG. 10c

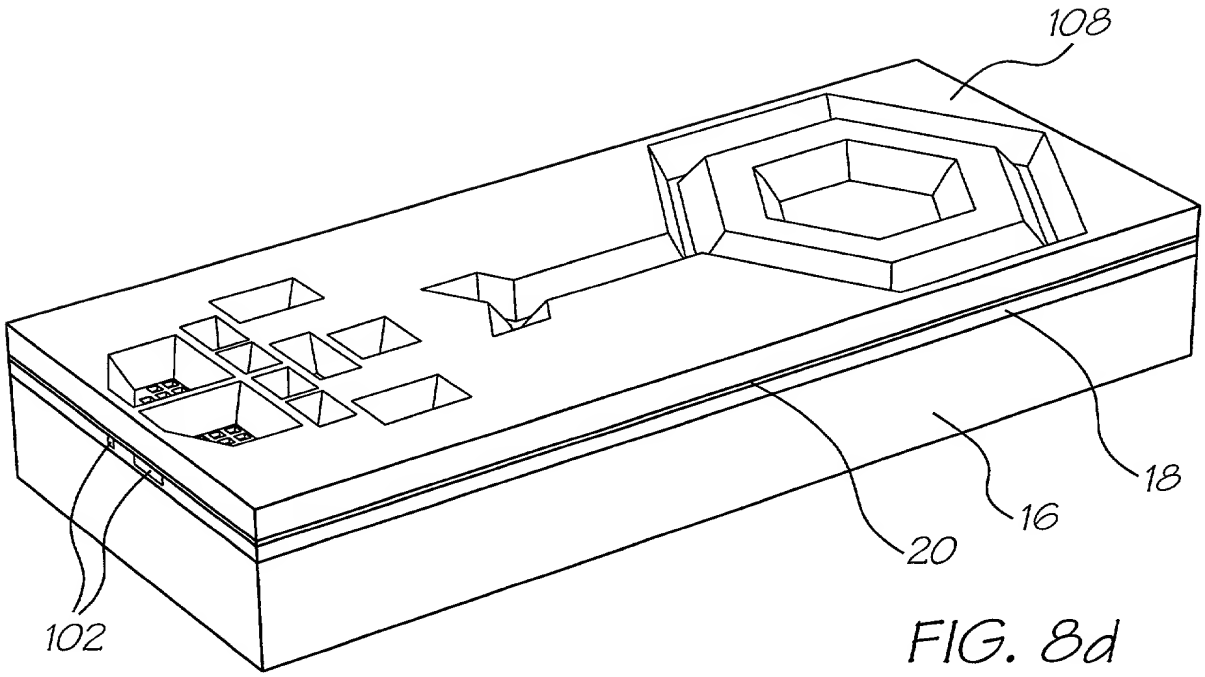

FIG. 8d

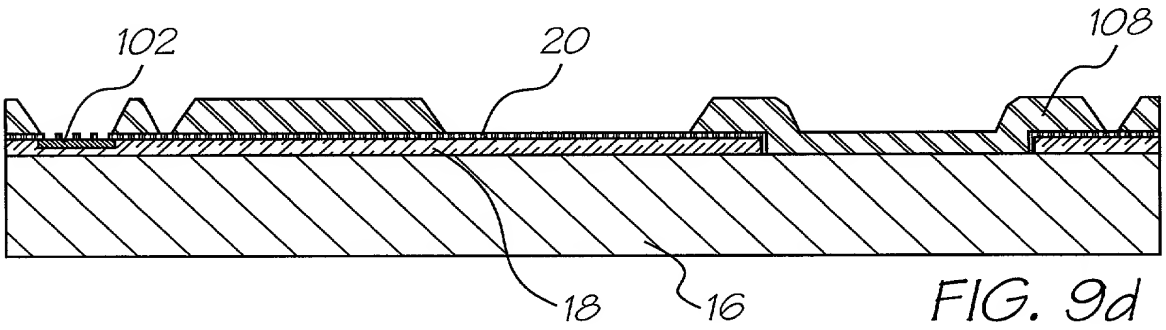

FIG. 9d

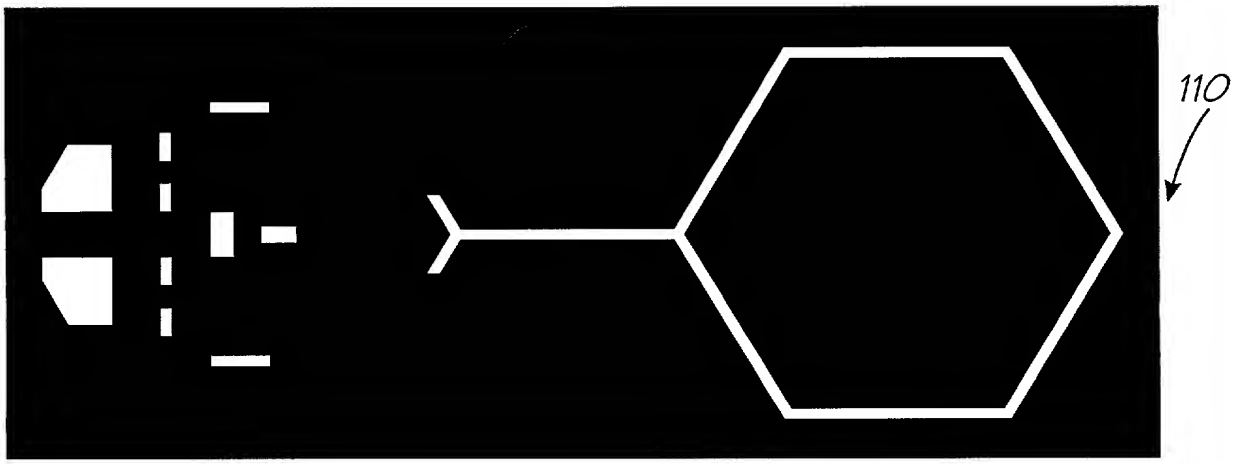

FIG. 10d

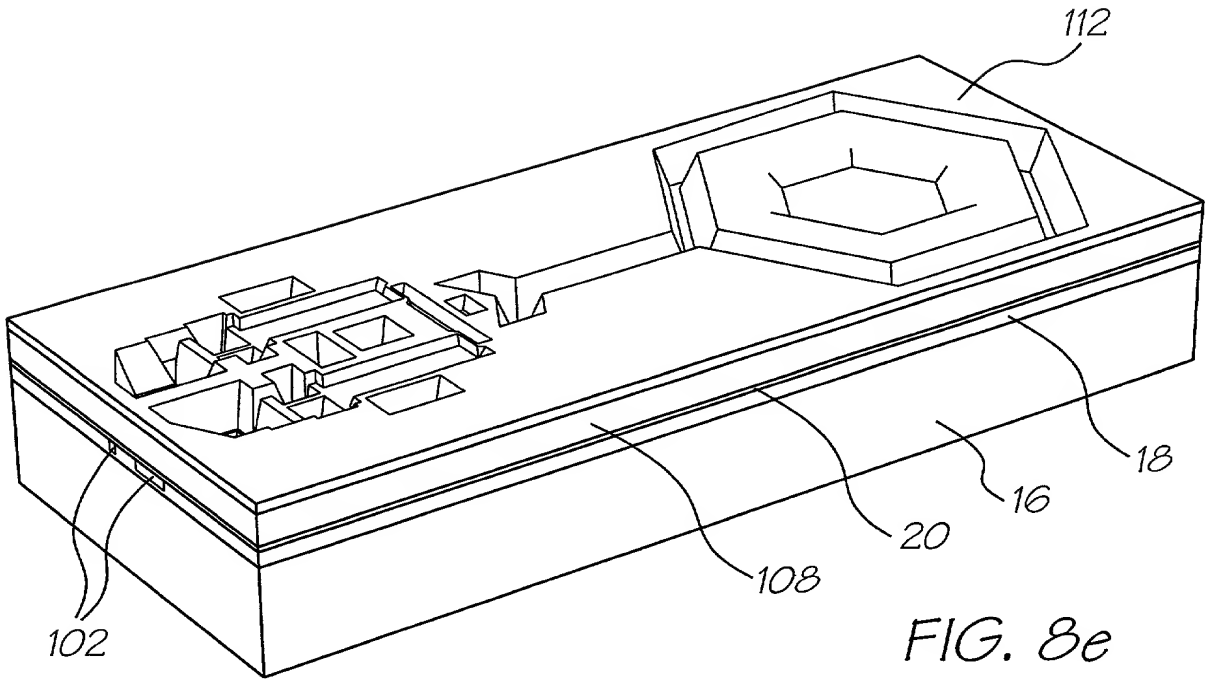

FIG. 8e

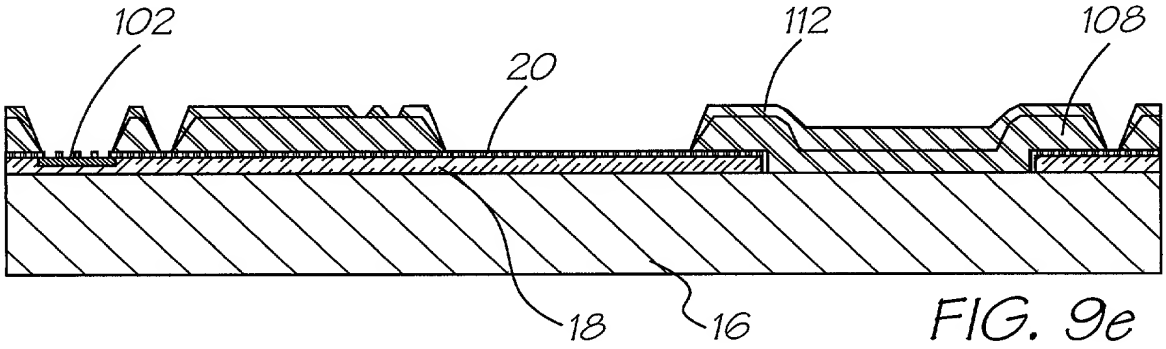

FIG. 9e

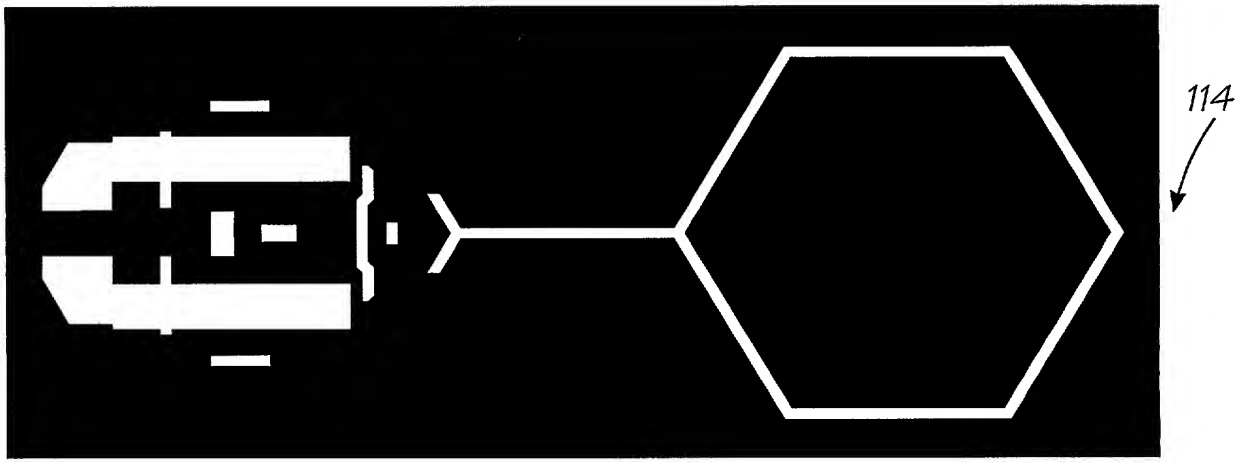

FIG. 10e

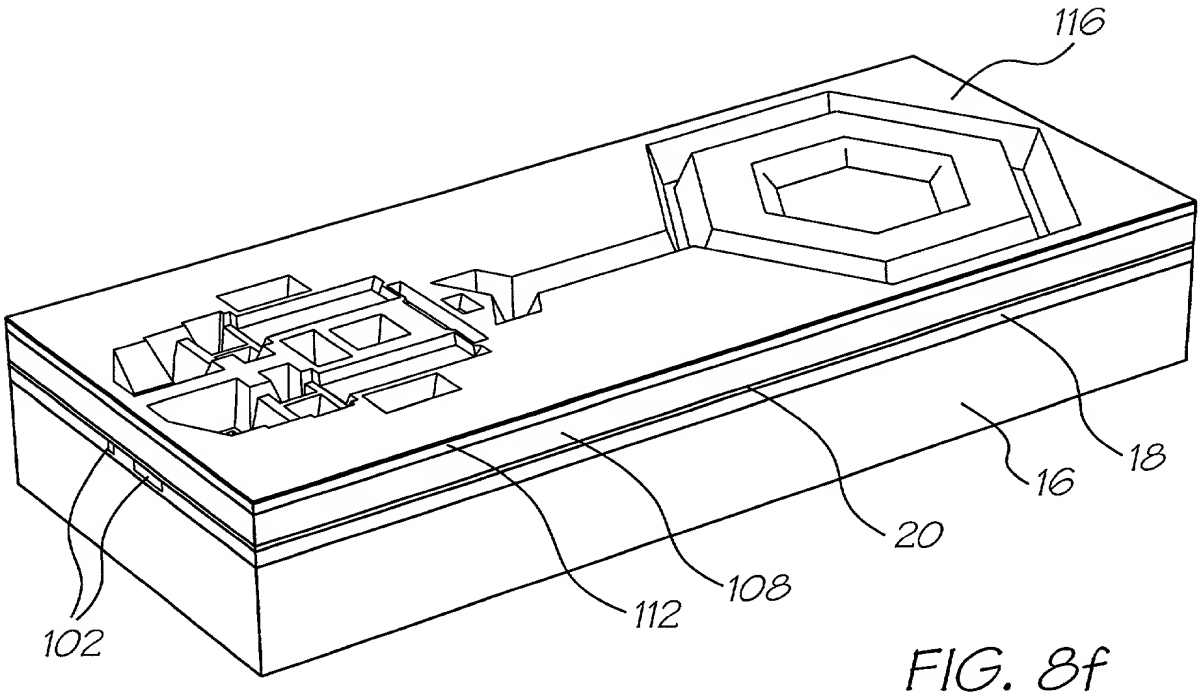

FIG. 8f

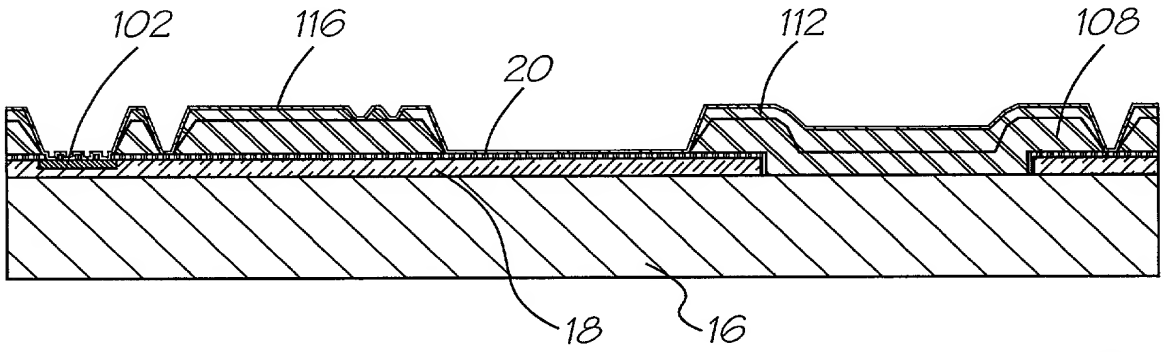

FIG. 9f

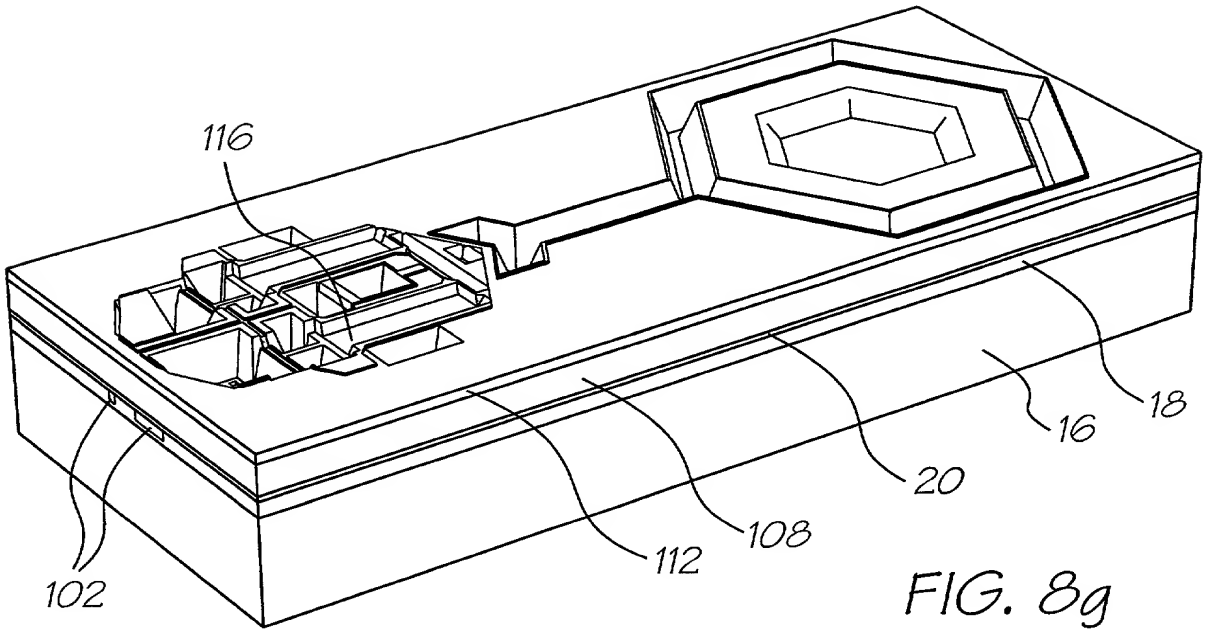

FIG. 8g

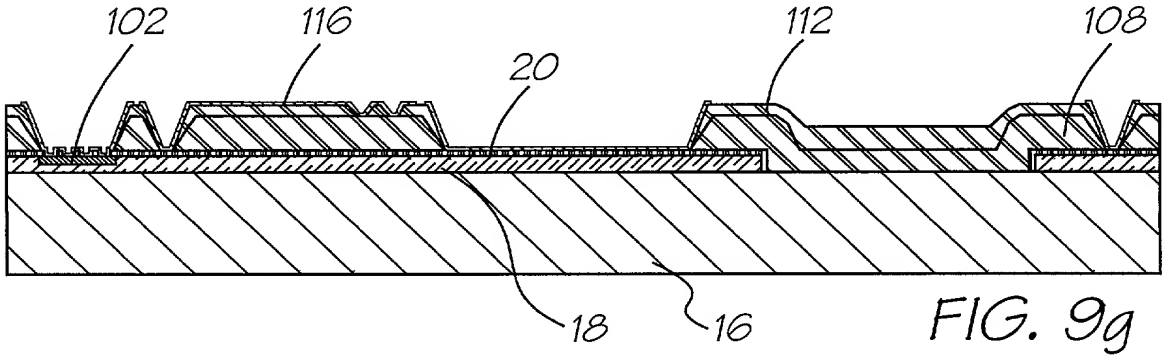

FIG. 9g

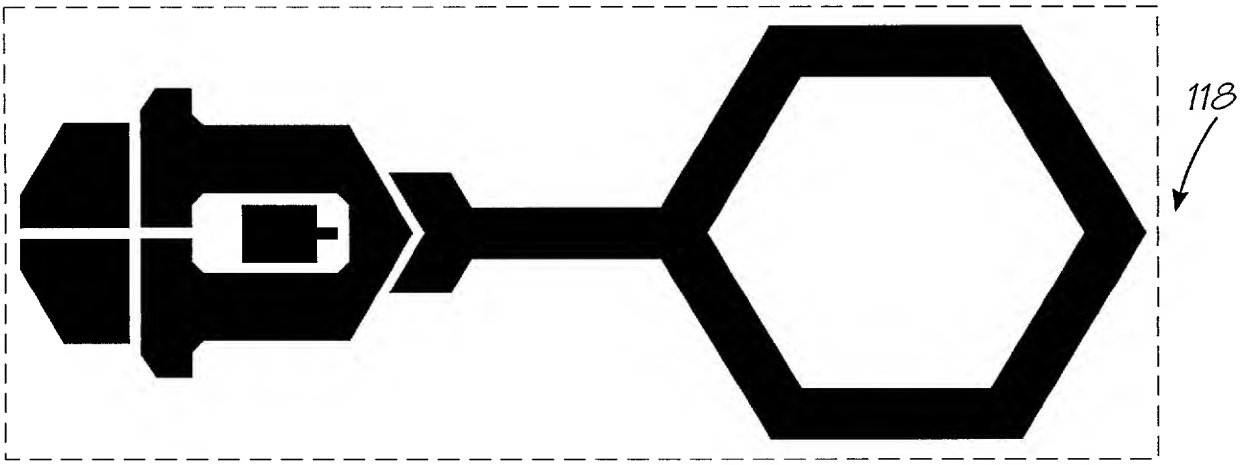

FIG. 10f

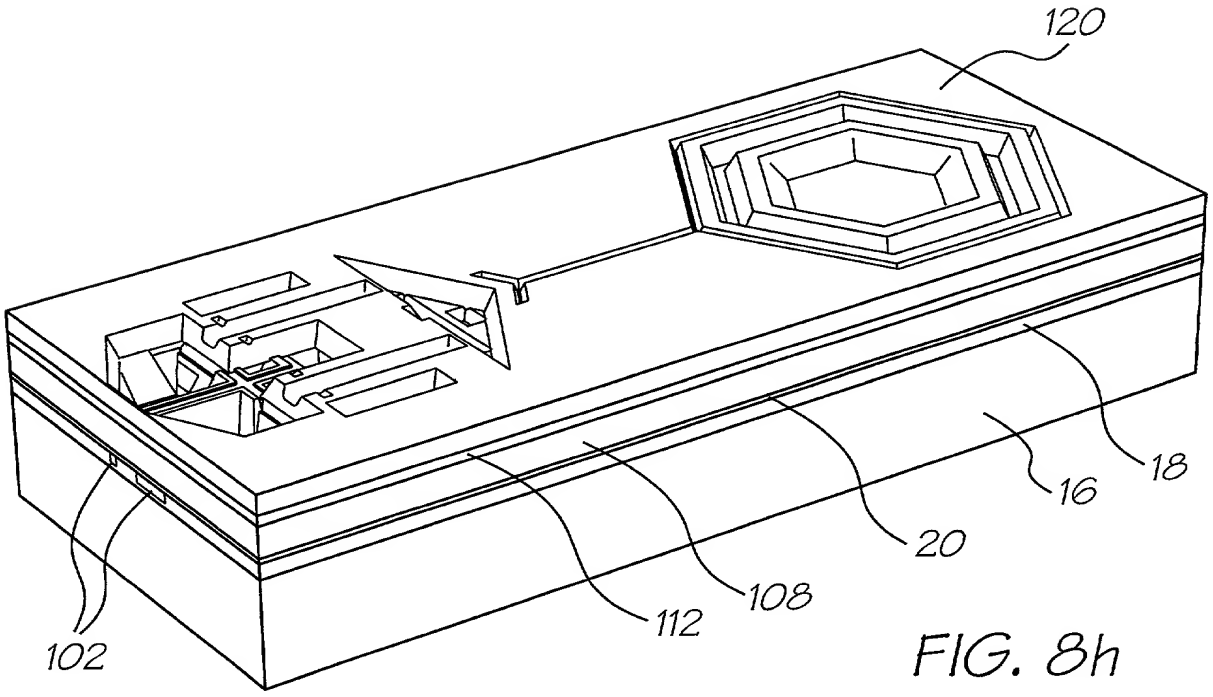

FIG. 8h

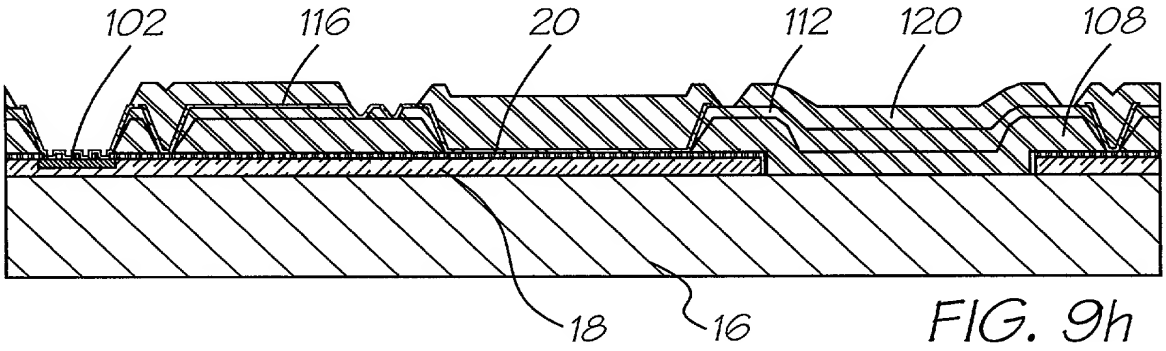

FIG. 9h

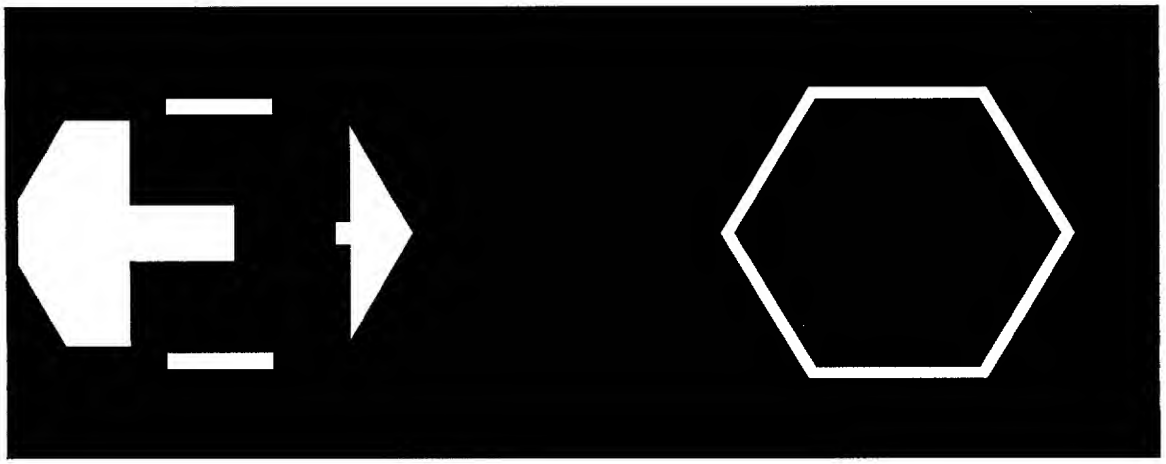

FIG. 10g

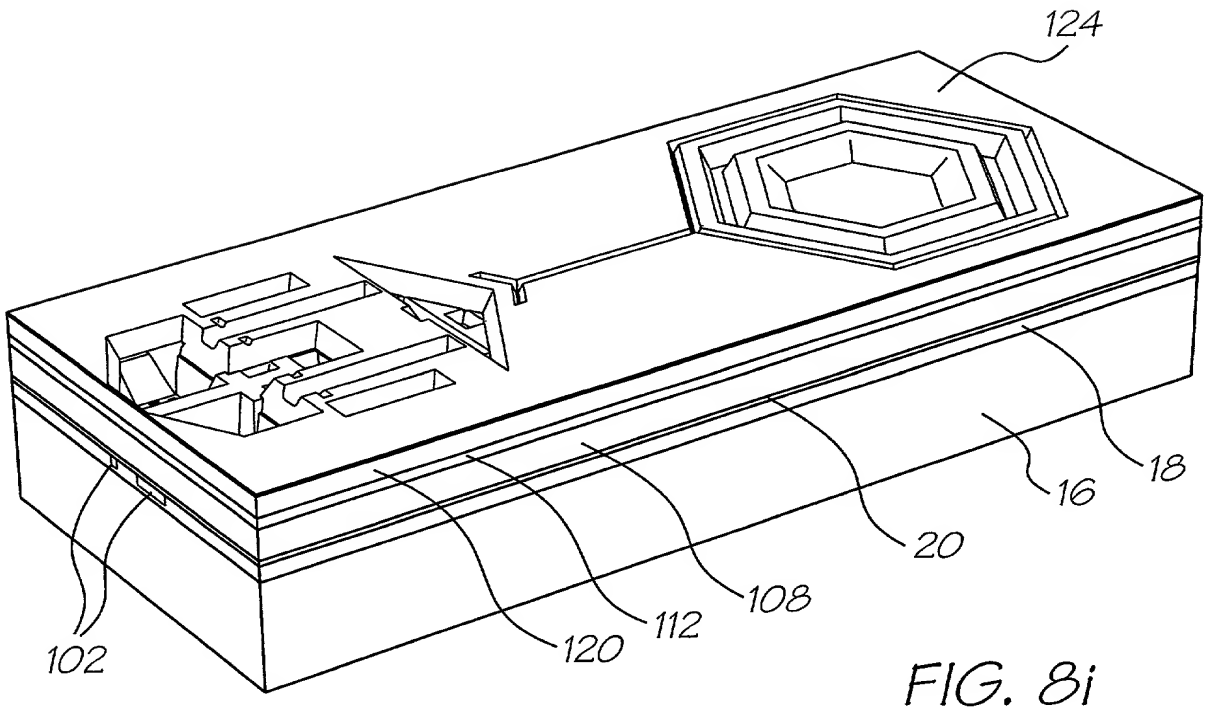

FIG. 8i

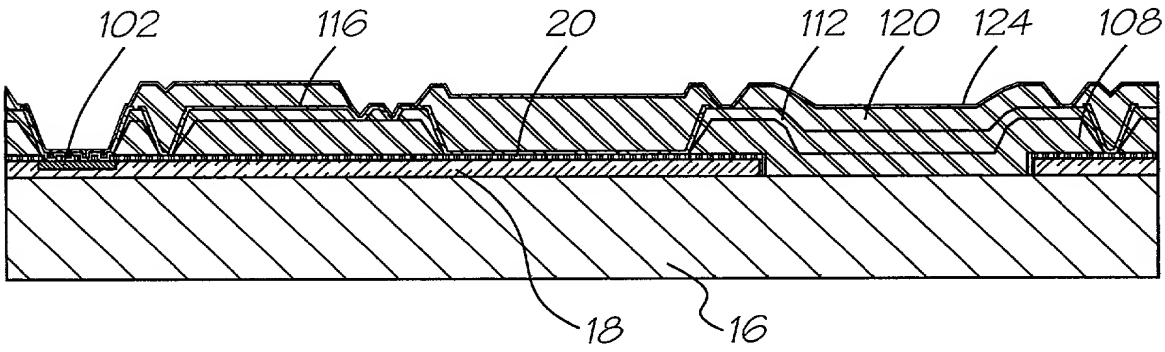

FIG. 9i

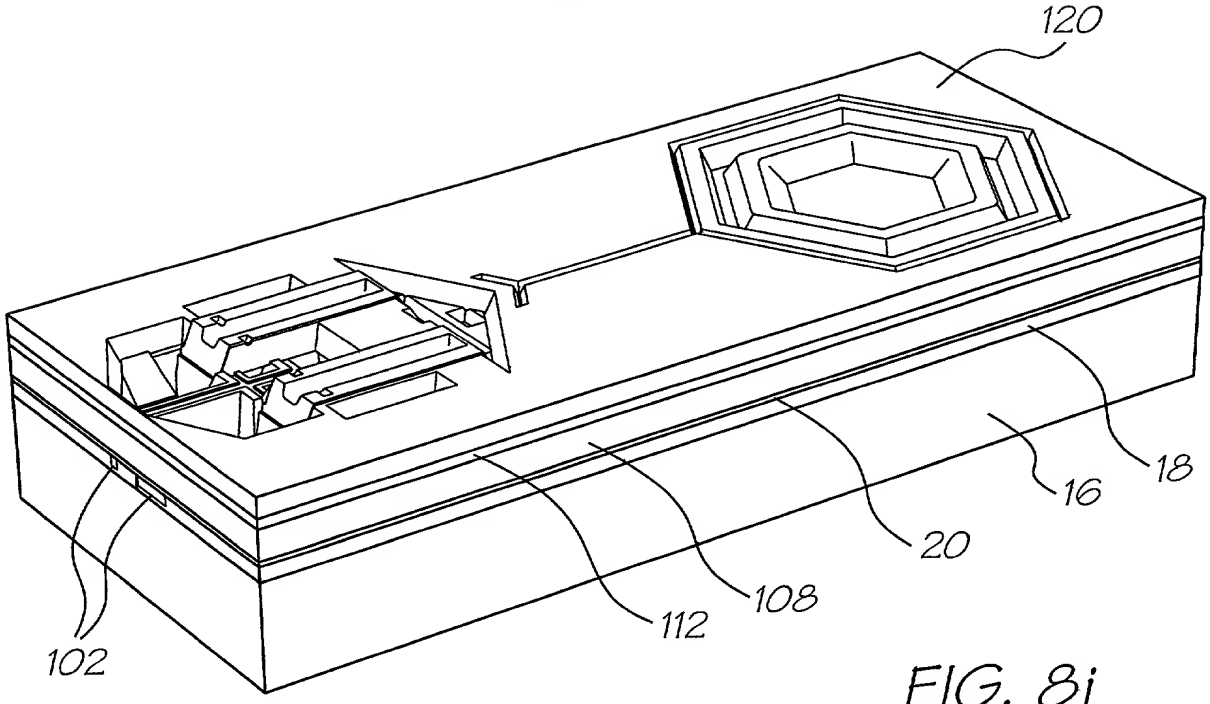

FIG. 8j

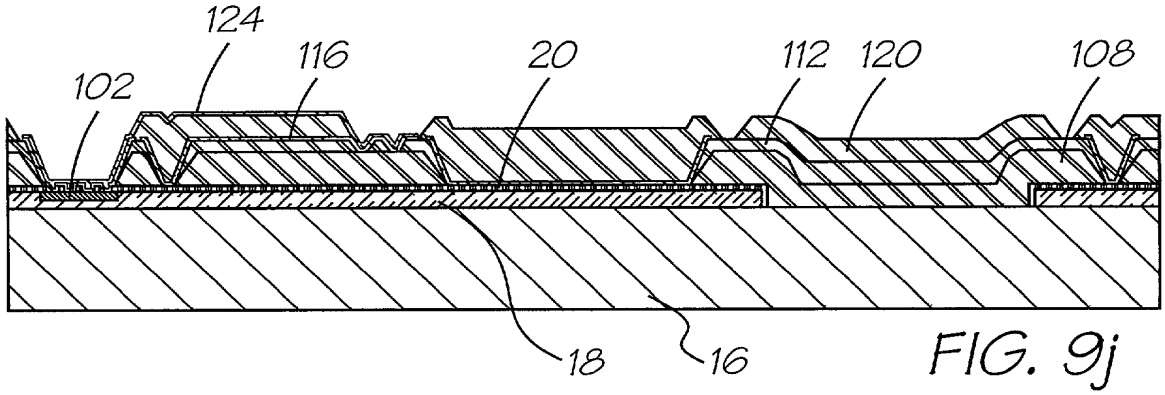

FIG. 9j

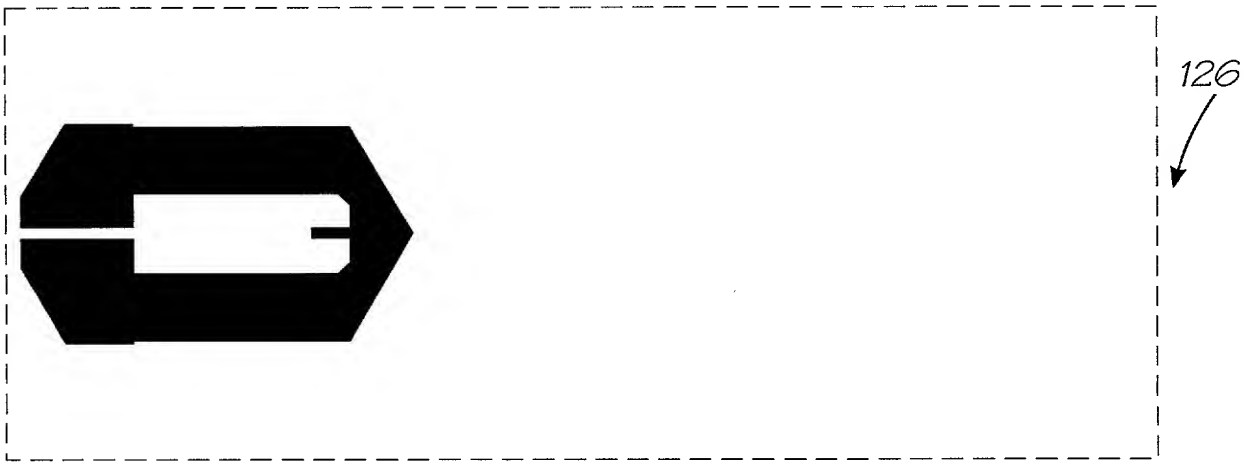

FIG. 10h

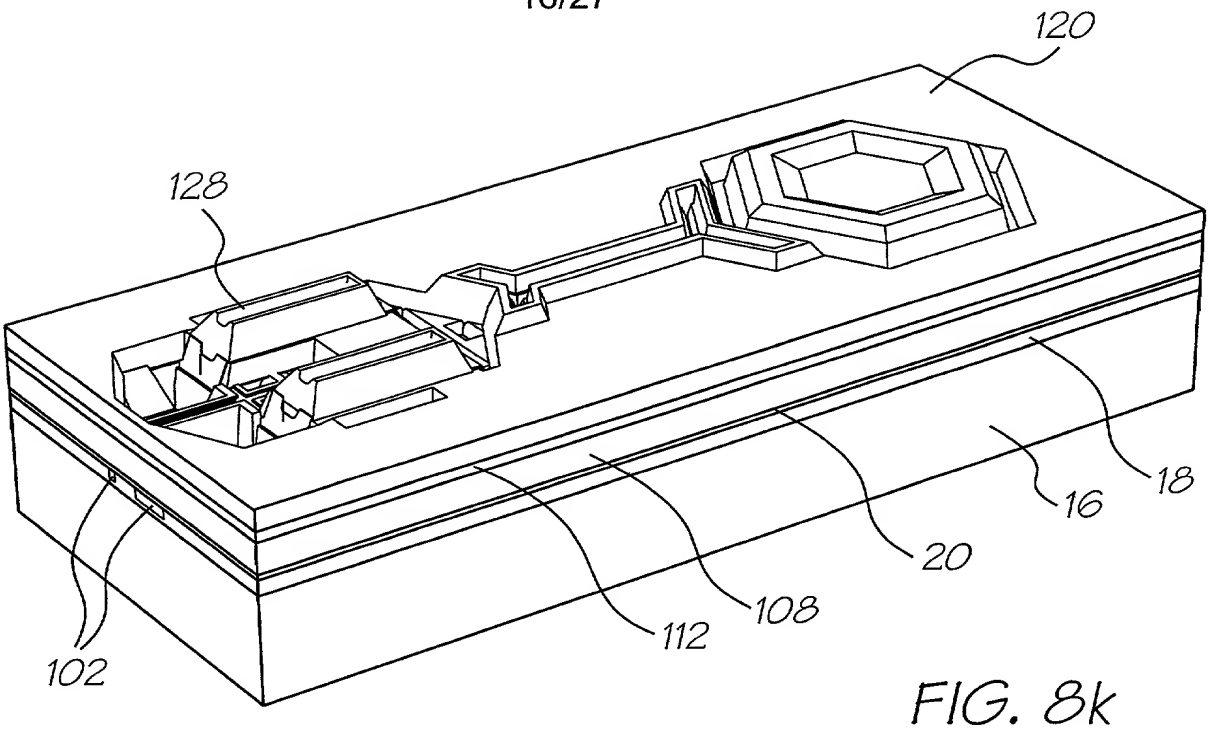

FIG. 8k

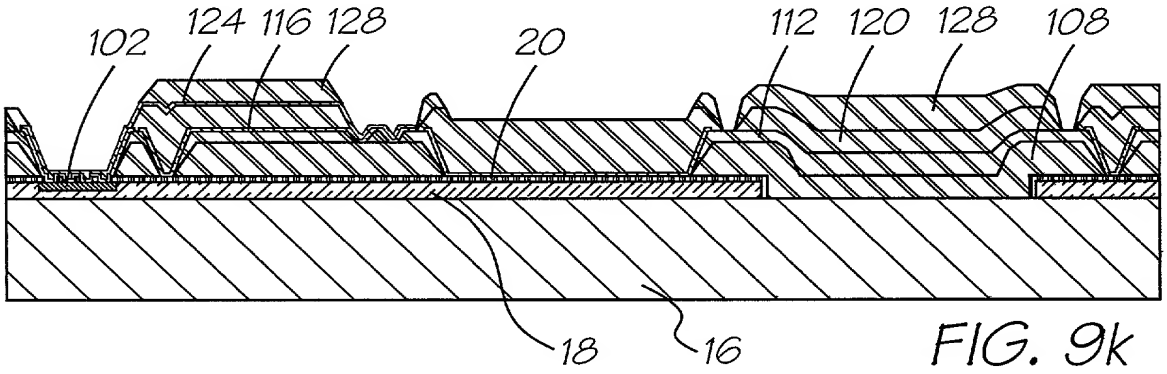

FIG. 9k

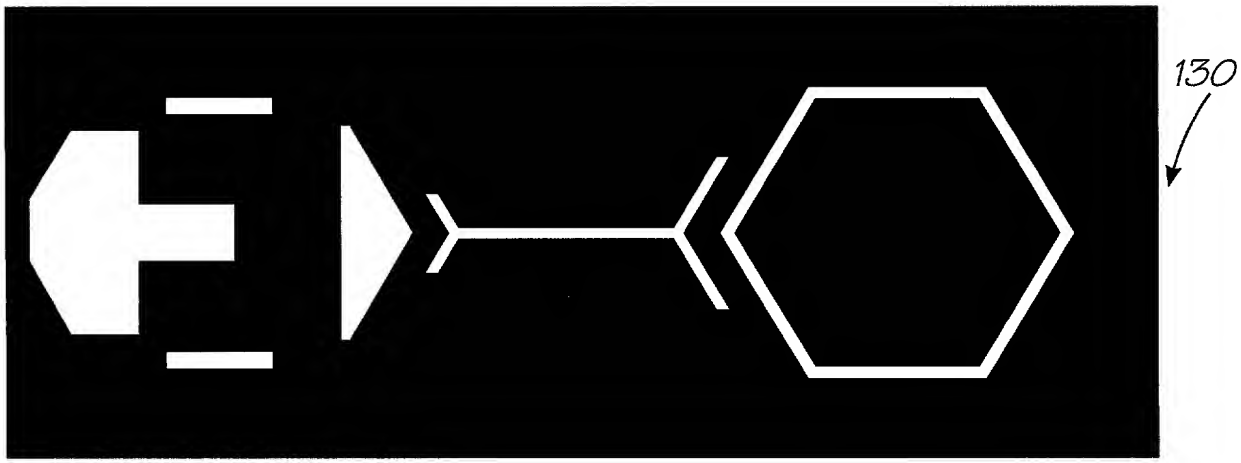

FIG. 10i

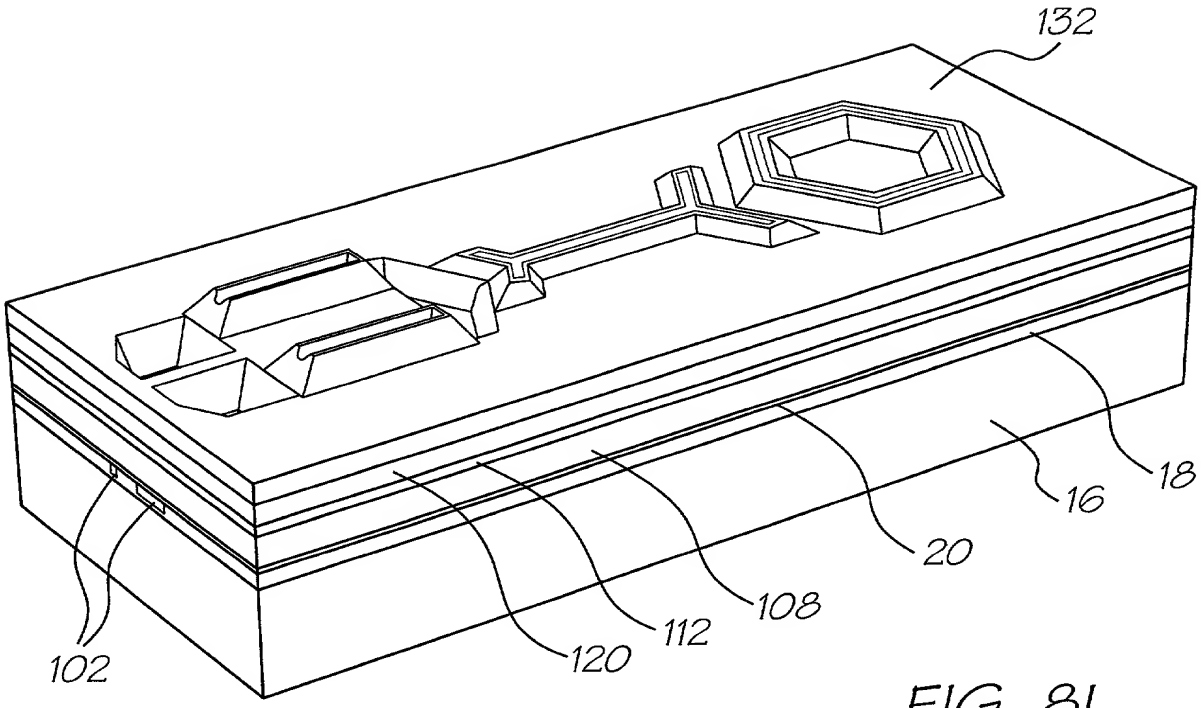
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FIG. 81

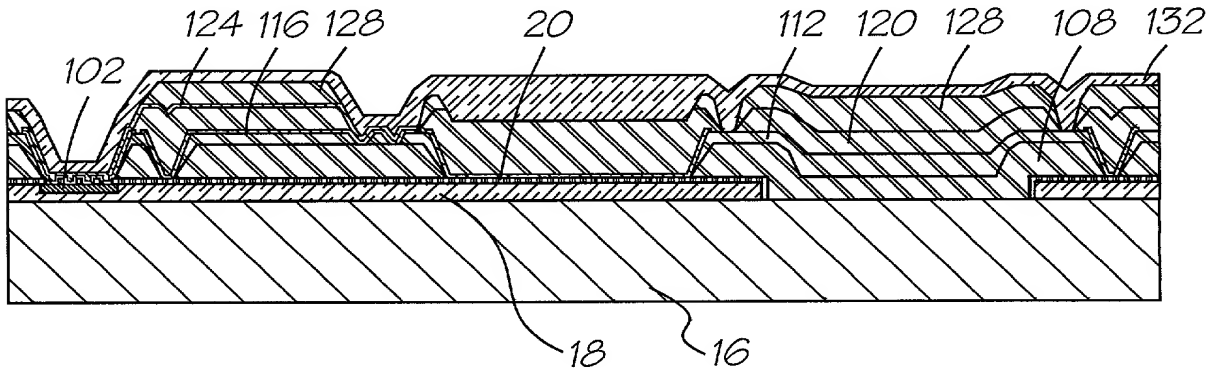
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FIG. 91

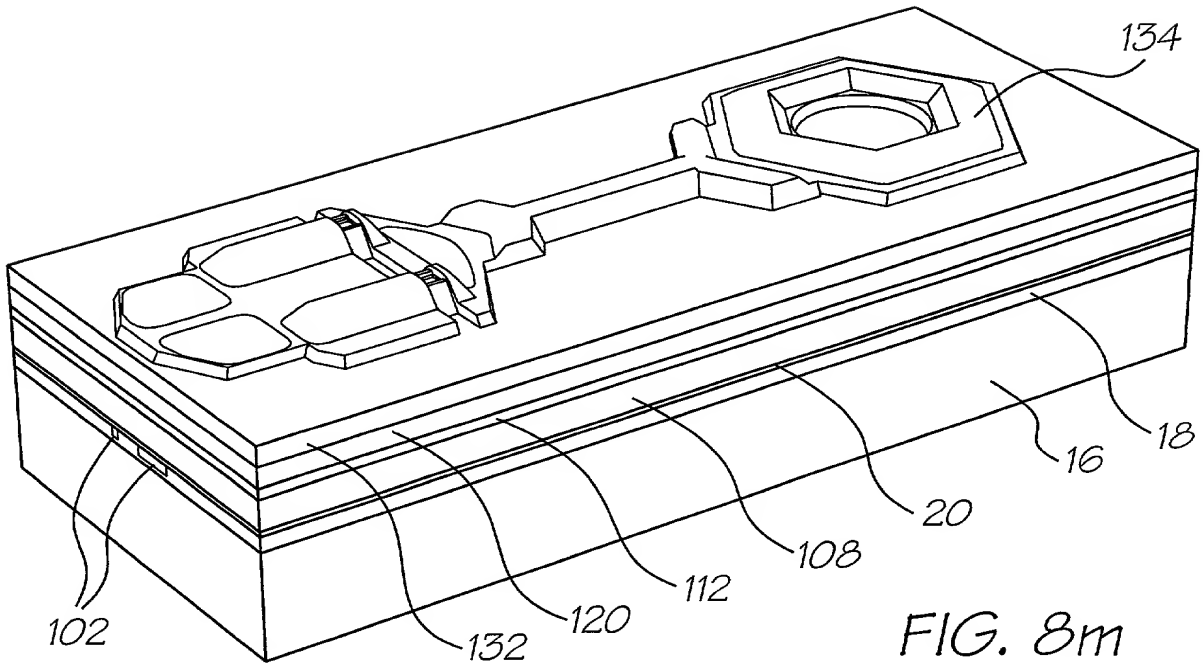

FIG. 8m

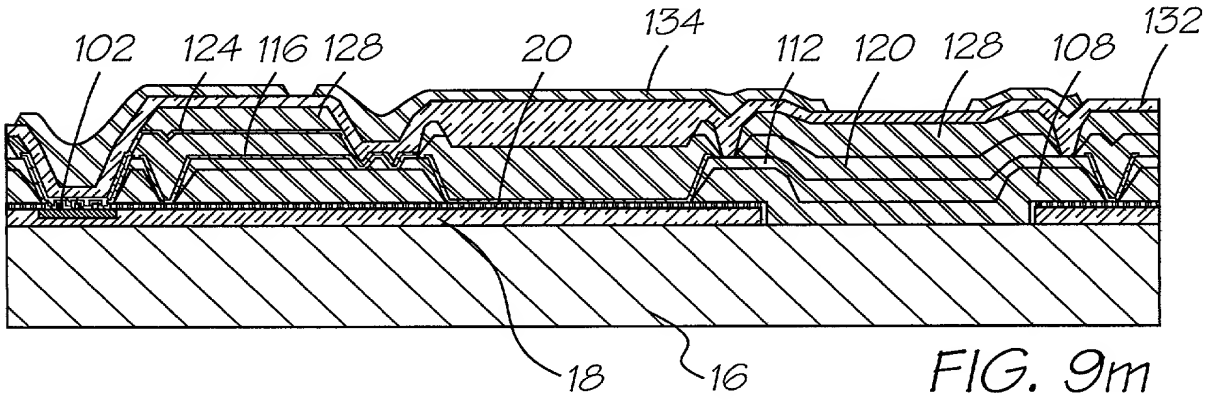

FIG. 9m

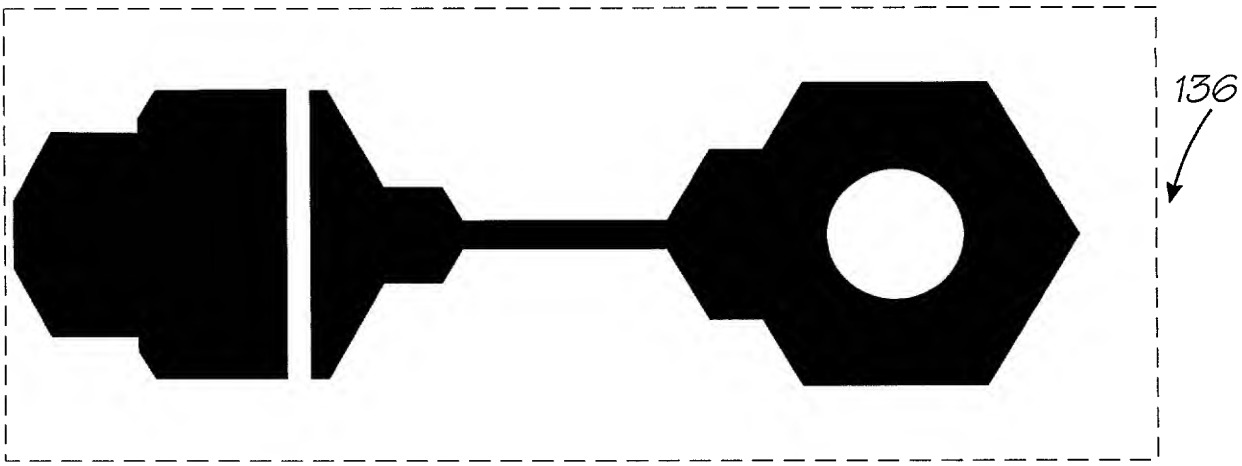

FIG. 10j

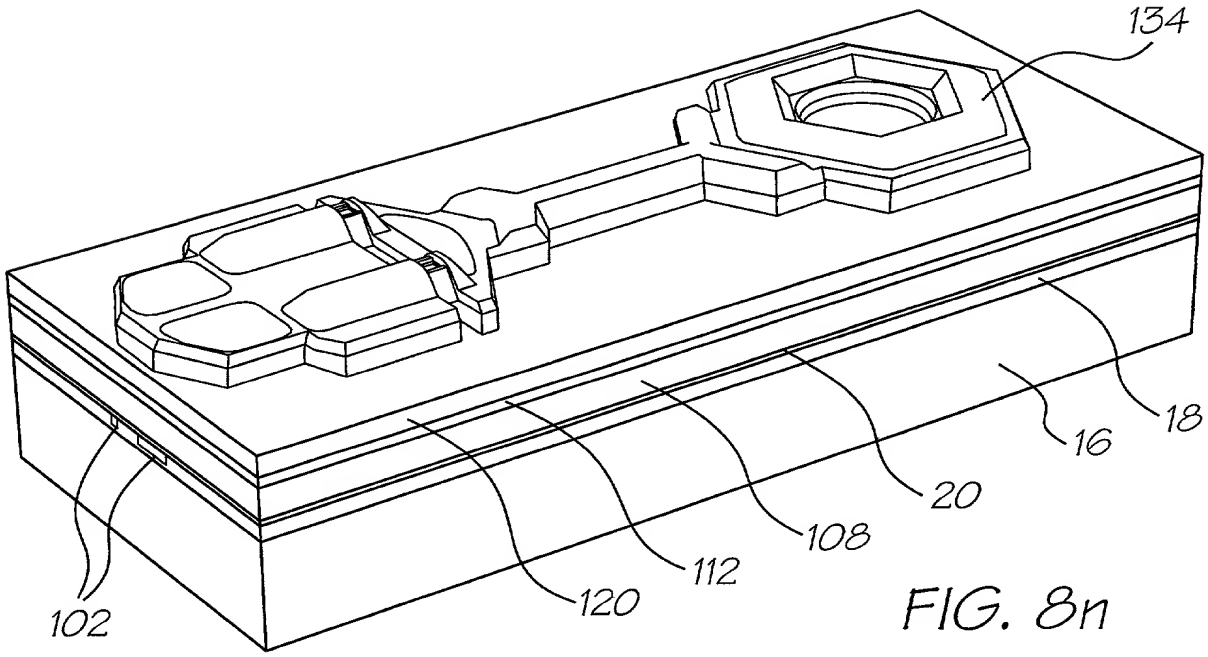
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FIG. 8n

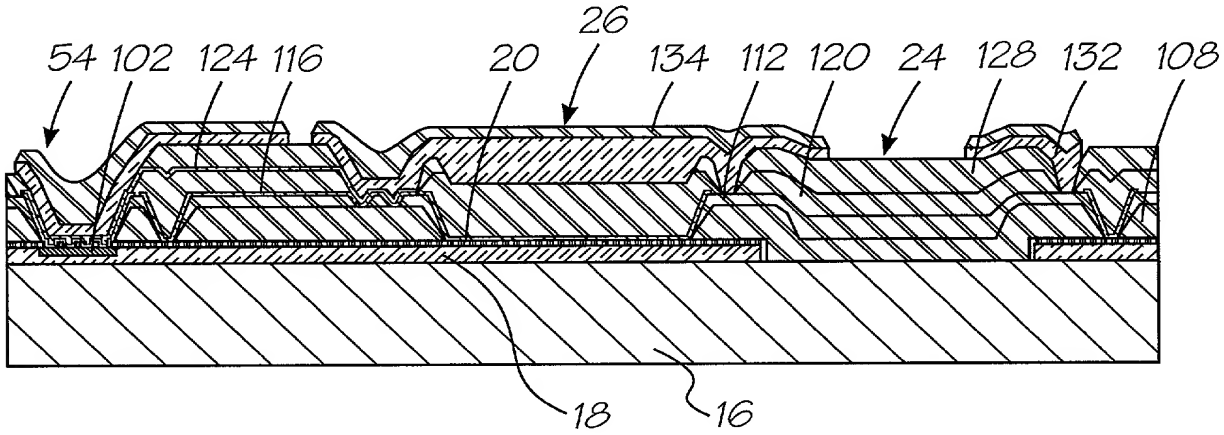
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FIG. 9n

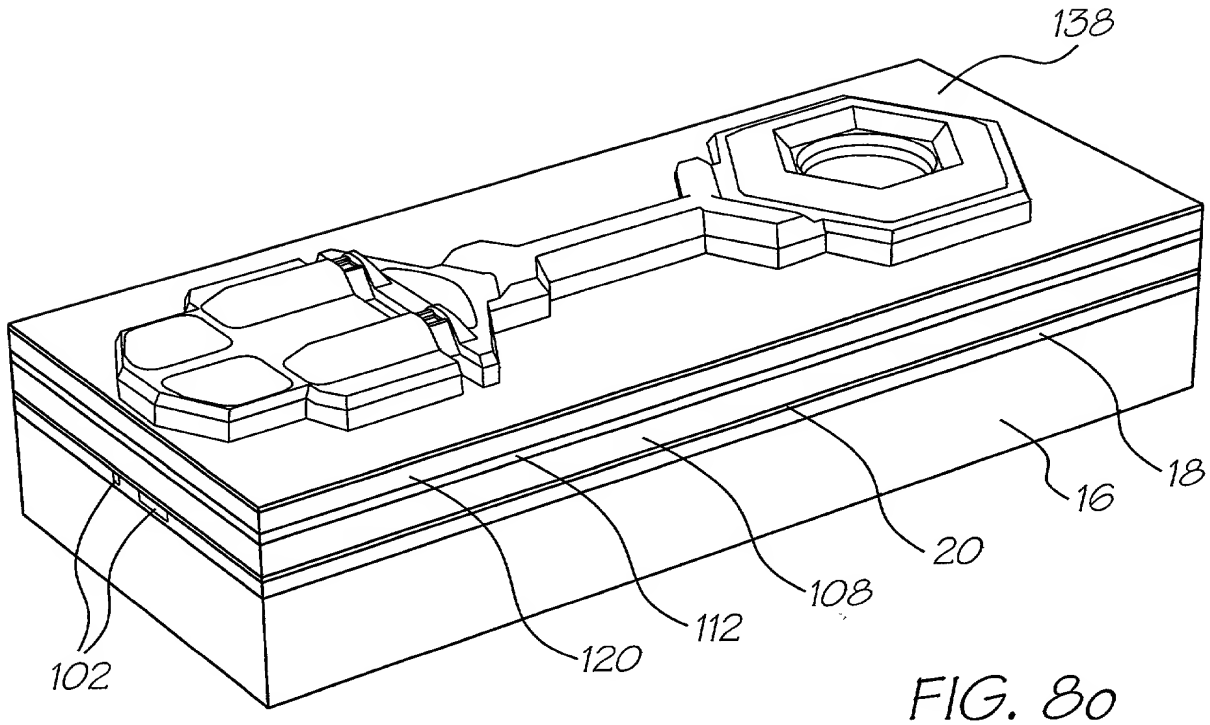
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FIG. 8o

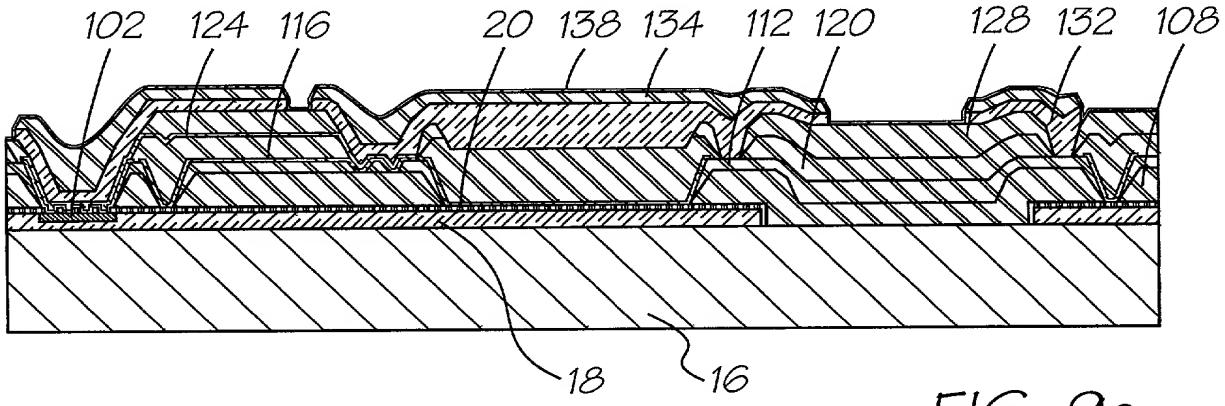
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FIG. 9o

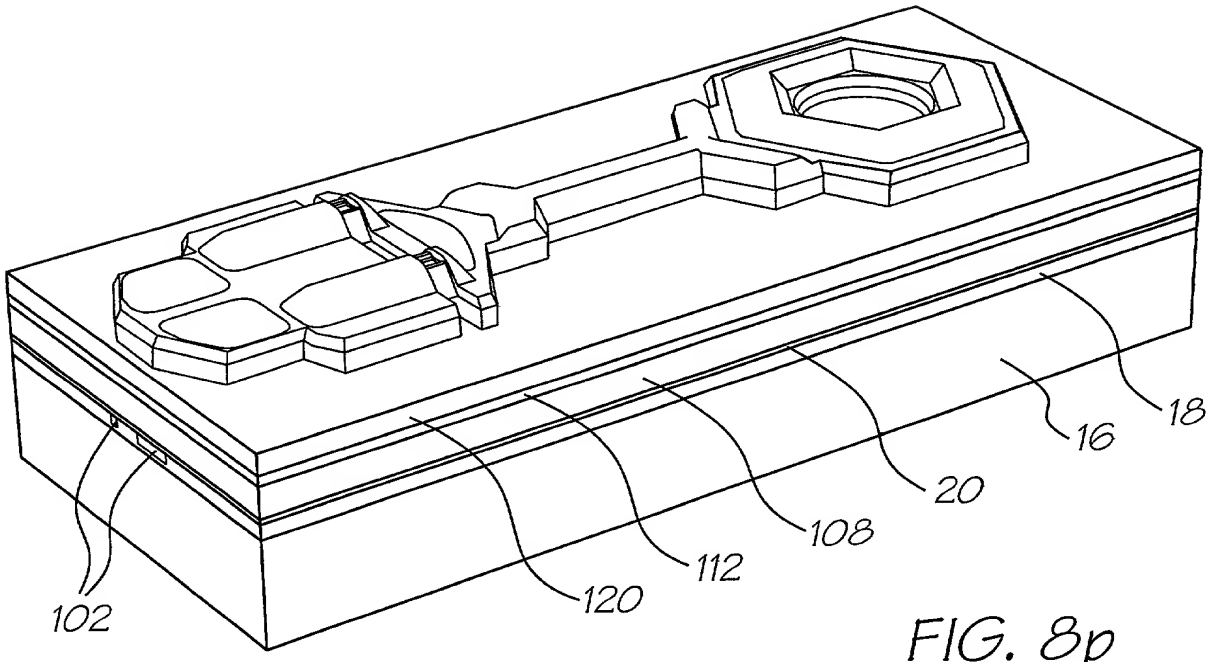
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FIG. 8p

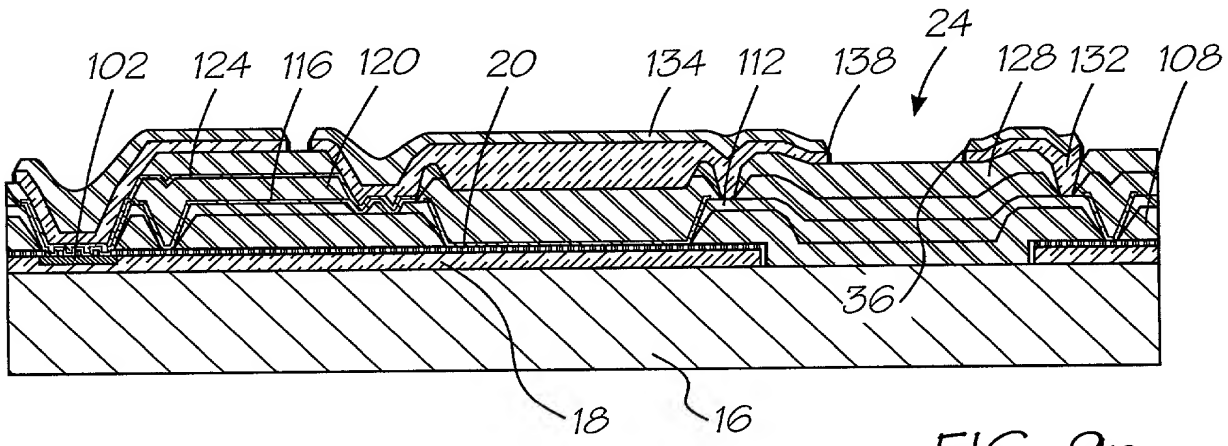
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FIG. 9p

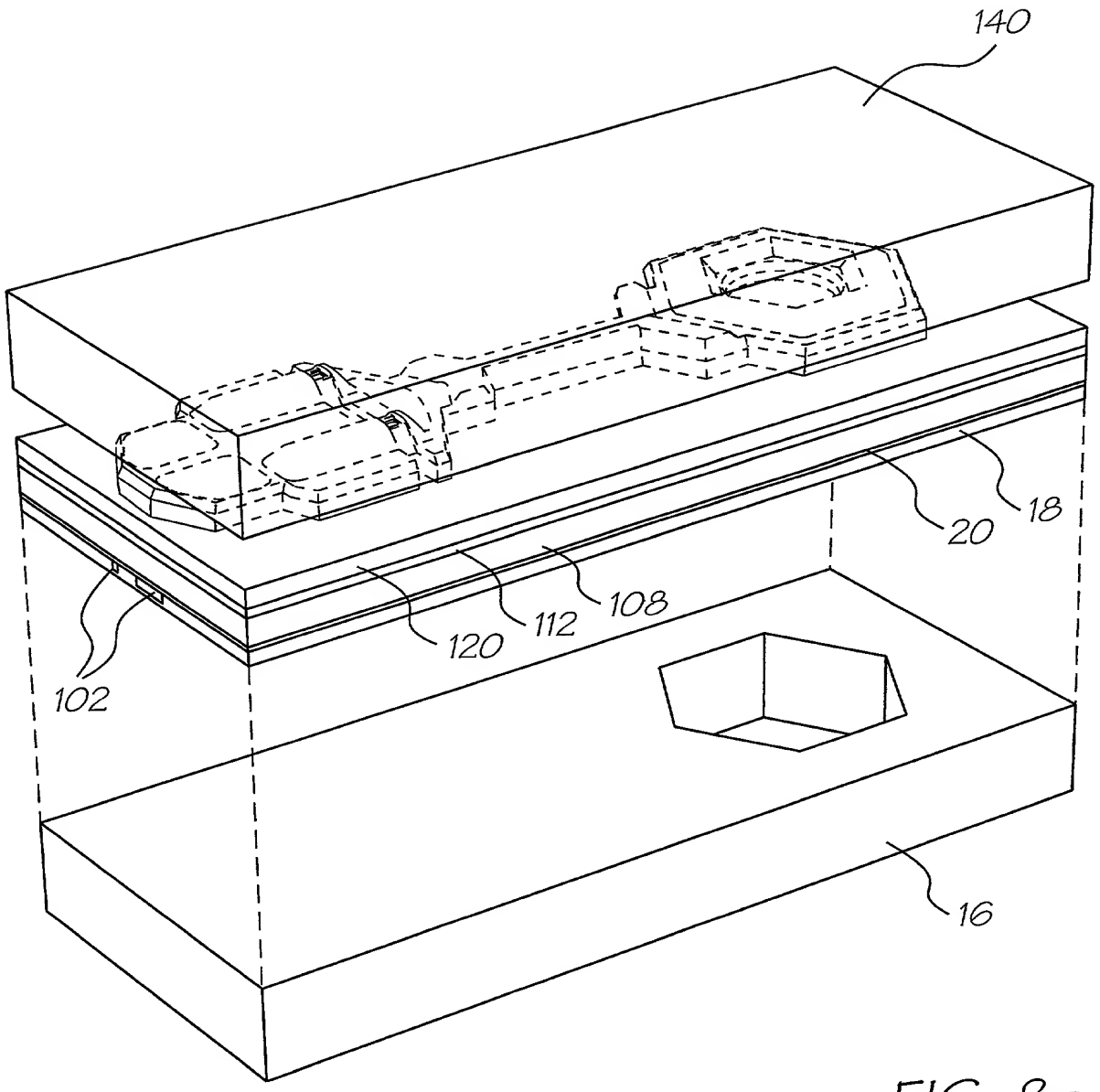

FIG. 8q

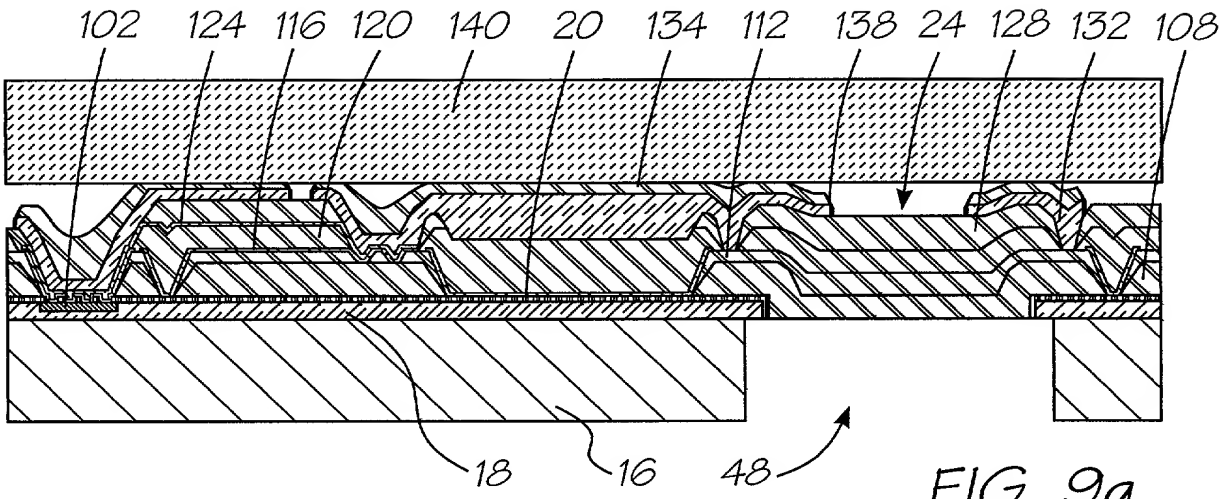

FIG. 9q

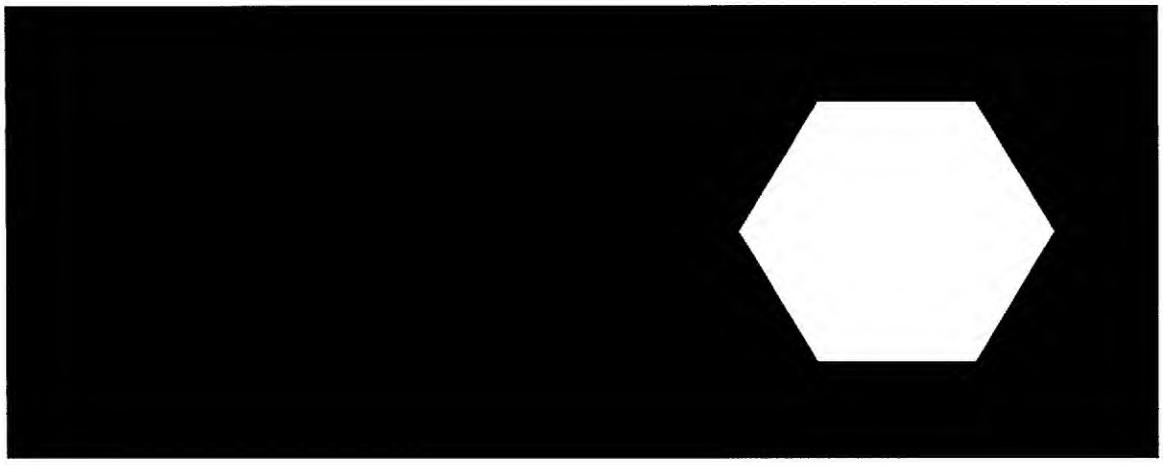

FIG. 10k

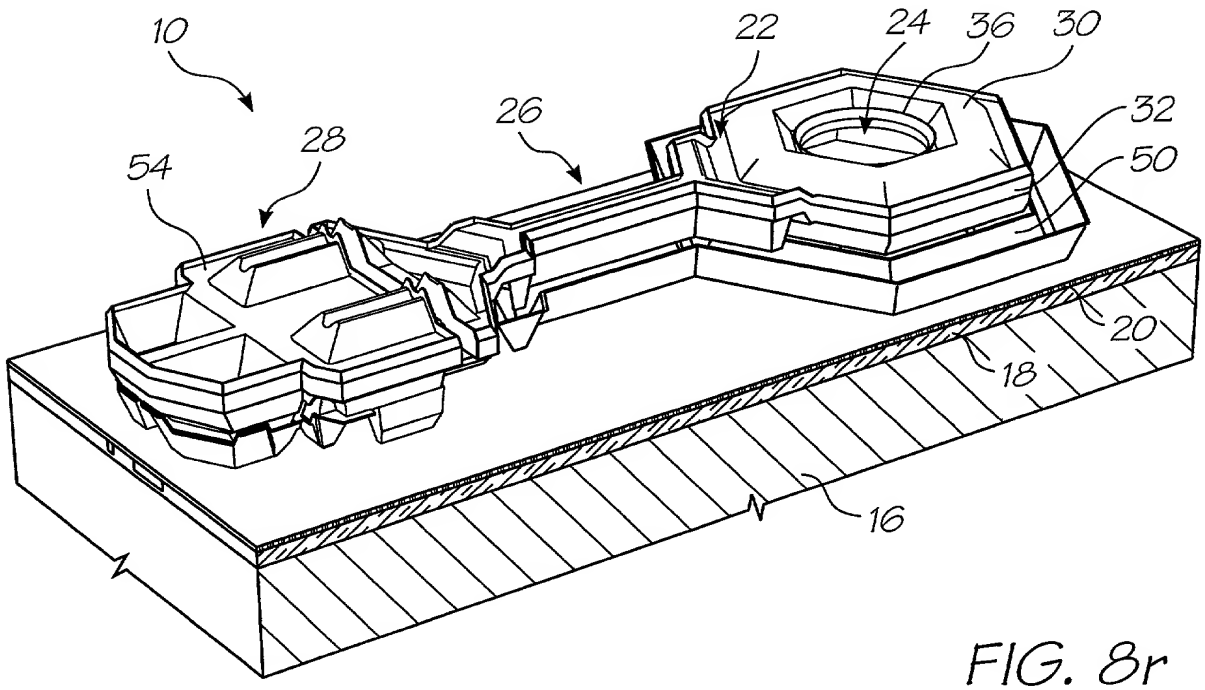
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FIG. 8r

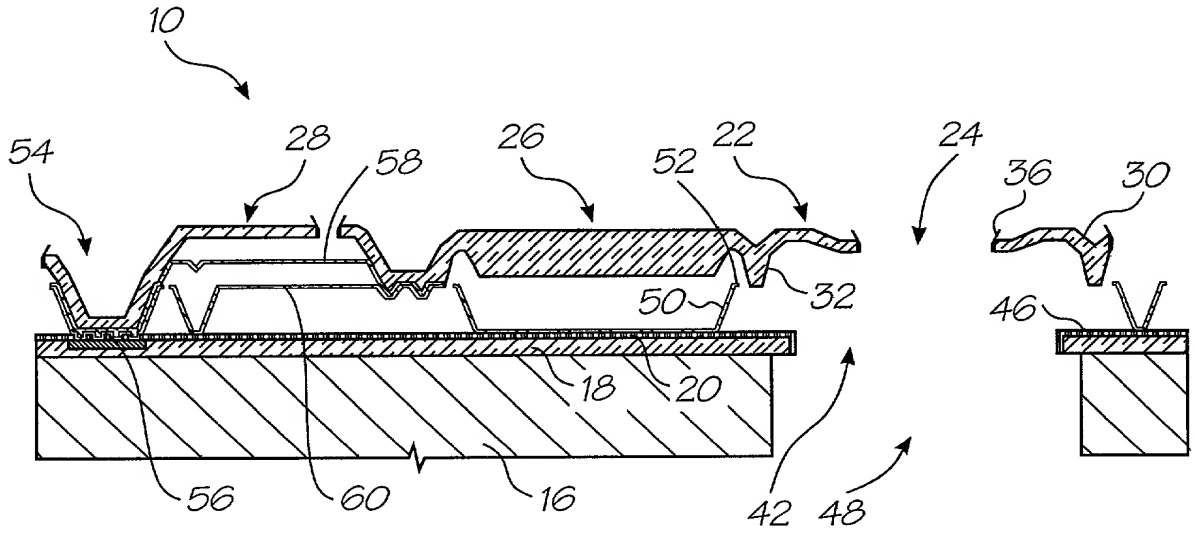
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FIG. 9r

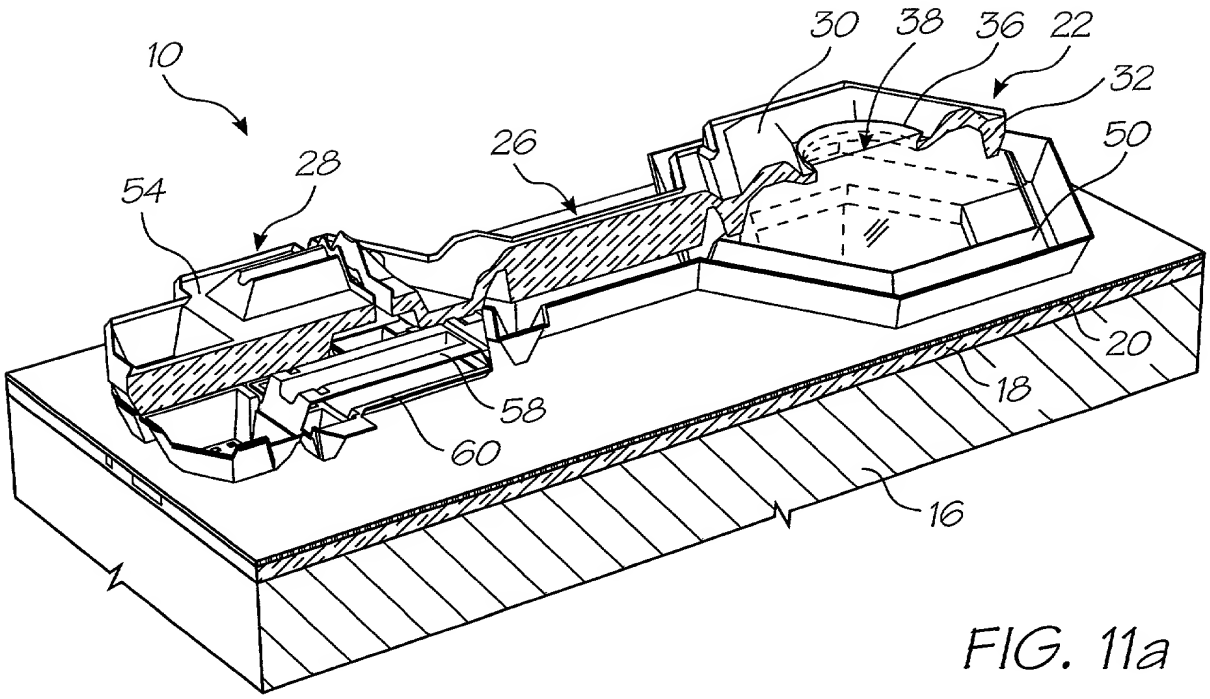

FIG. 11a

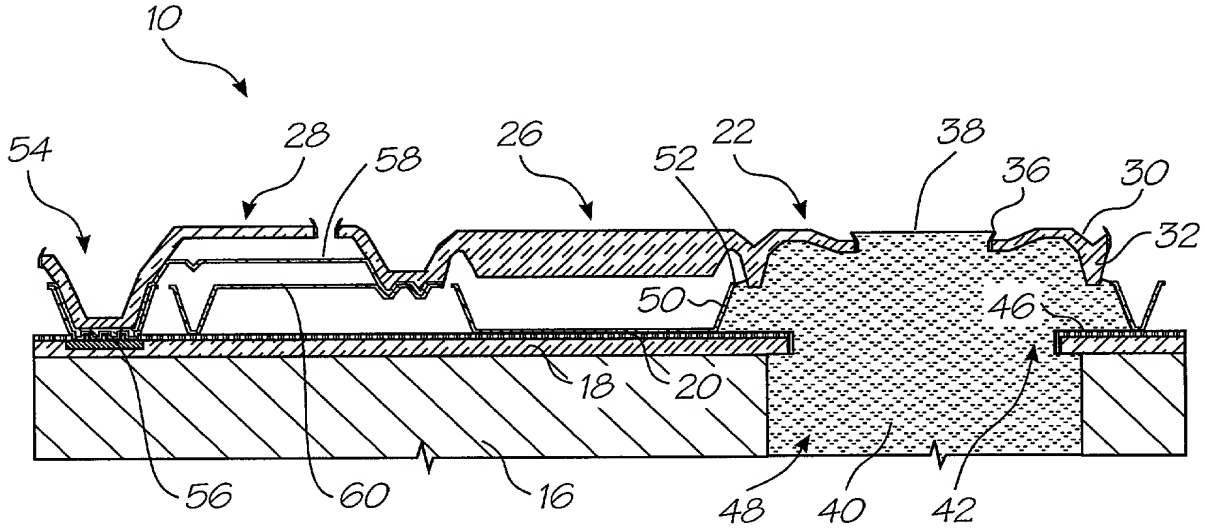

FIG. 12a

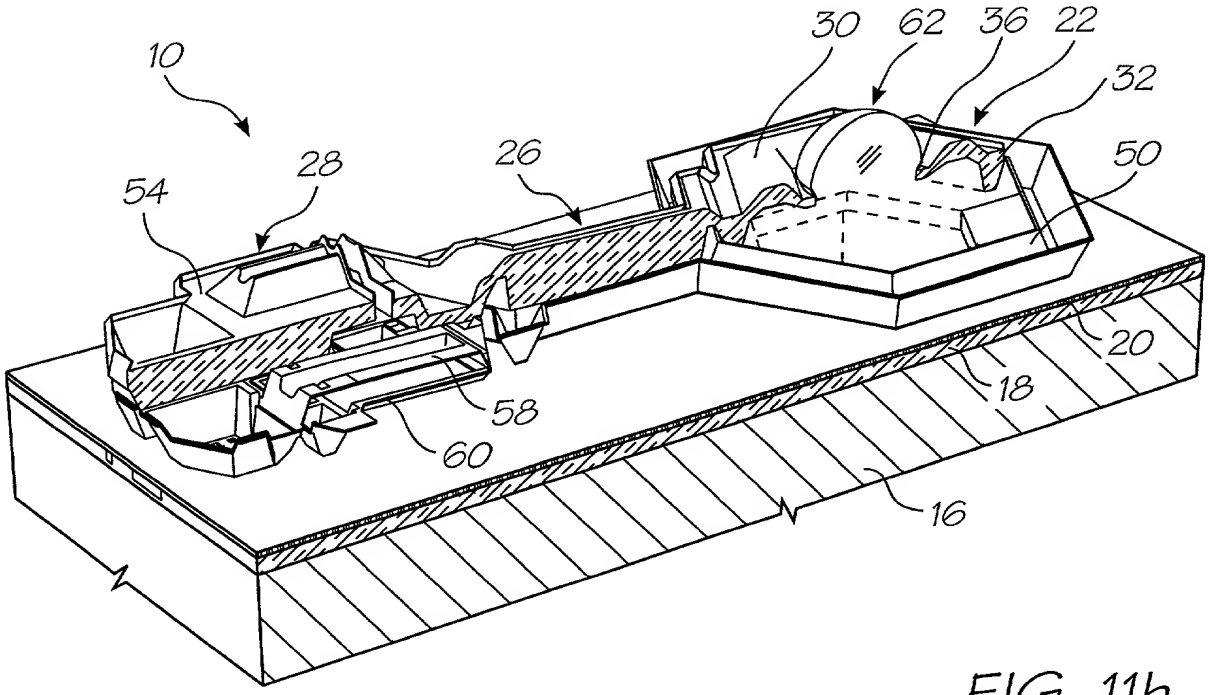

FIG. 11b

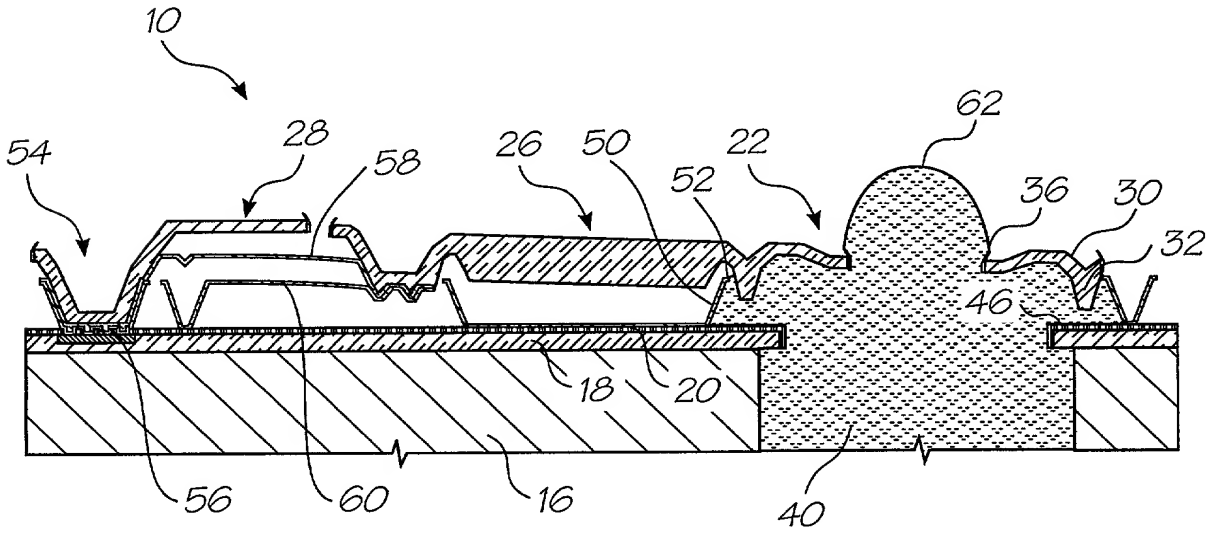

FIG. 12b

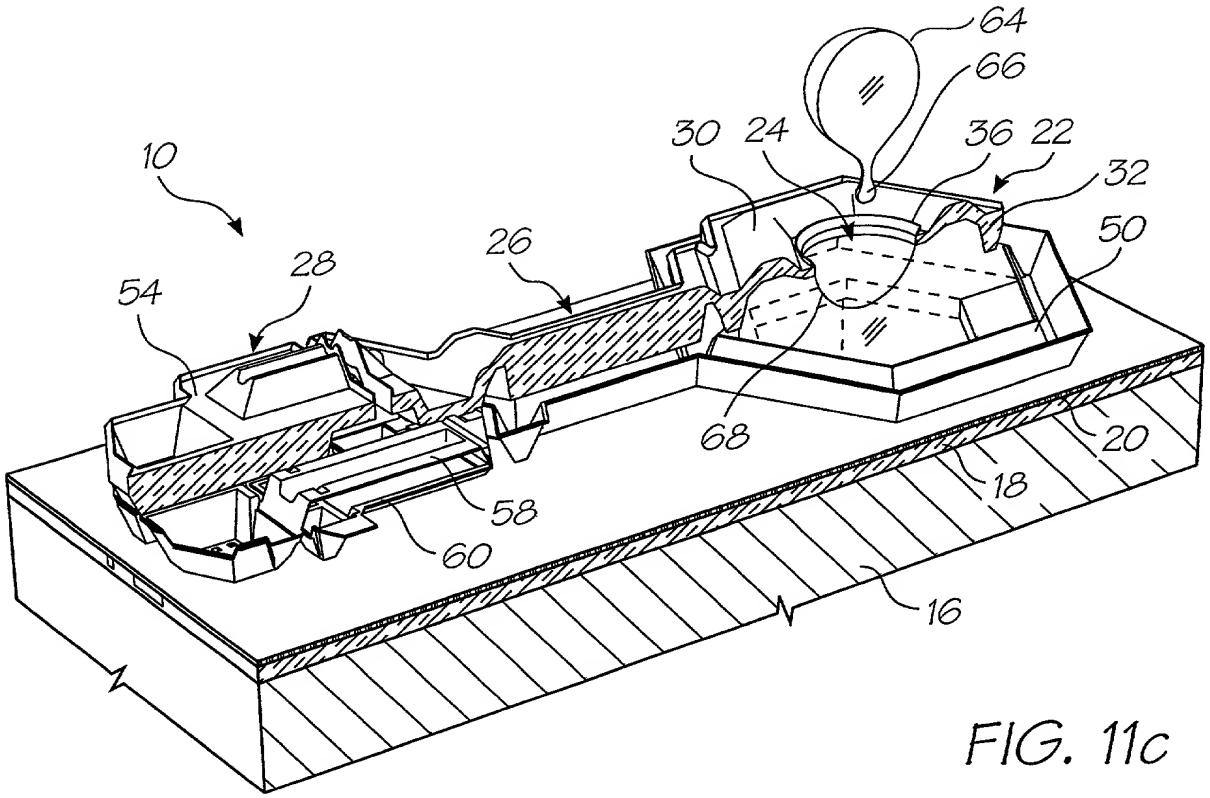

FIG. 11c

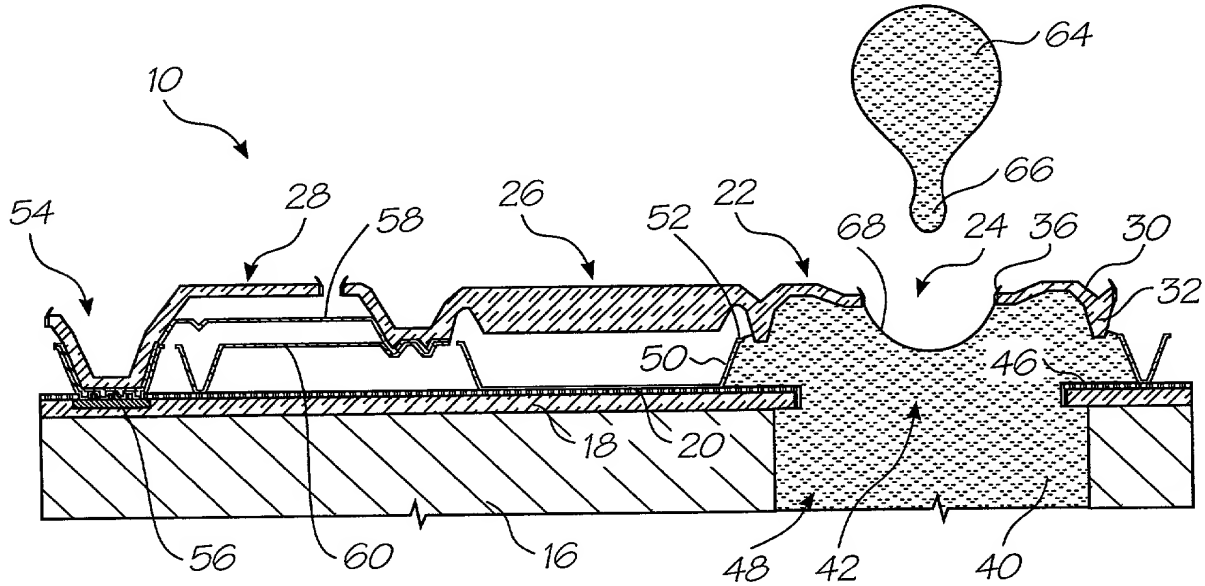

FIG. 12c

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☒ Declaration Submitted with Initial Filing **OR** ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	MJ21US
First Named Inventor	KIA SILVERBROOK
COMPLETE IF KNOWN	
Application Number	/
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

PRINTED MEDIA PRODUCTION

(Title of the Invention)

the specification of which
☒ is attached hereto
OR
☐ was filed on (MM/DD/YYYY) _____ as United States Application Number or PCT International Application Number _____ and was amended on (MM/DD/YYYY) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U S C 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number *(if applicable)*

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*
OR
☐ Registered practitioner(s) name/registration number listed below

Name	Registration Number	Name	Registration Number

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☒ Customer Number or Bar Code Label [24011] *OR* ☐ Correspondence address below

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Country	Australia	**Telephone**	61-2-9818-6633			**Fax**	61-2-9818-6711

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
KIA	SILVERBROOK

Inventor's Signature						**Date**	Oct. 18, 2000
Residence: City	Balmain	**State**	NSW	**Country**	Australia	**Citizenship**	Australian
Post Office Address	393 Darling Street						
Post Office Address							
City	Balmain	**State**	NSW	**ZIP**	2041	**Country**	Australia

☐ Additional inventors are being named on the ____supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto